EU4Dual

EUROPEAN SCIENTIFIC JOURNAL FOR

VOL. 2 / NUMBER 1 / JUNE 2026

DUAL HIGHER EDUCATION.

ISSN: 3052-7015

This journal is part of
EU4DUAL

IMPRINT

European Scientific Journal for Dual Higher Education (ESJ DHE)

ISSN (online): *3052-7015*

Publisher: *EU4Dual European University Alliance*

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Citation Information: Please cite this journal as: *European Scientific Journal for Dual Higher Education (ESJ DHE), Vol. 2, Number 1 (2026)*. DOI prefix: https://doi.org/10.82321

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EDITORIAL — THE SOCIETALLY RELEVANT DUAL HIGHER EDUCATION – EMPOWERING AGENCY IN A CHANGING WORLD

European Scientific Journal for Dual Higher Education (ESJ DHE), Vol. 2, No. 1, (2026)

Prof. Dr. phil. habil. Ulf-Daniel Ehlers[1]

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Dear readers,

It is my great pleasure to introduce the second issue of the *European Scientific Journal for Dual Higher Education*. With this issue, the journal continues its mission to establish a European scholarly platform for research, theory, and practice in dual and work-integrated higher education. As part of the EU4Dual European University Alliance, the journal contributes to a field that is becoming increasingly important for higher education systems, labour markets, regions, and democratic societies.

Dual higher education is often described as a model that connects academic study and professional practice. This is correct, but it is not enough. At its best, dual higher education does more than organise learning across two sites. It brings society into the heart of academic education. It connects universities with companies, public institutions, civil society, regions, and communities. It asks students not only to understand the world, but to act in it, to reflect on it, and to contribute to its transformation. This makes dual higher education one of the most promising laboratories for rethinking the university itself.

In a time shaped by digital transformation, artificial intelligence, sustainability transitions, demographic change, geopolitical uncertainty, and social fragmentation, higher education cannot remain confined to the transmission of established knowledge. Universities must enable learners to act responsibly in open, uncertain, and complex situations. They must foster agency, critical judgement, ethical reflection, collaboration, and the capacity to shape change. These are not additional skills at the margins of academic education. They are becoming central conditions for academic and professional formation.

From this perspective, dual higher education is not merely a response to labour-market needs. It is a model of societal relevance. It shows how academic learning can be embedded in real challenges, how professional practice can become a site of inquiry, and how students can develop competence through experience, reflection, responsibility, and action. No other form of higher education brings society into academic learning with the same structural intensity.

However, if dual higher education is to become a truly European model, it must be researched. It must be described, compared, theorised, evaluated, and critically discussed across countries, disciplines, and institutional traditions. Europe does not yet share one common understanding of dual higher education. The field is shaped by different legal frameworks, historical pathways, pedagogical cultures, labour-market structures, and institutional designs. This diversity is a strength, but only if we develop the concepts and evidence needed to understand it.

This is why research matters. Research helps us make dual higher education mutually intelligible across Europe. It allows us to see what is specific to national systems and what may be transferable across borders. It helps us distinguish between structural arrangements and pedagogical quality, between formal cooperation and meaningful integration, between employability rhetoric and genuine competence development. In this sense, research on dual higher education is also research for European integration. It creates a shared language, a shared evidence base, and

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a shared space for dialogue among universities, employers, regions, policymakers, students, and researchers.

The *European Scientific Journal for Dual Higher Education* was founded precisely for this purpose. It is not only a publication outlet. It is an intellectual infrastructure for an emerging European field. It supports the development of concepts, methods, evidence, and debates that allow dual higher education to become visible as a serious object of scholarship and as a driver of higher education innovation.

The contributions in this issue demonstrate the richness and diversity of this field. They address dual higher education from empirical, conceptual, comparative, strategic, and bibliometric perspectives. Together, they show that dual and work-integrated learning is not a marginal or merely practice-oriented format, but a dynamic area of research with major implications for curriculum design, quality development, competence formation, innovation, and societal transformation.

The opening article by Iraia Urkia-Basterra, Paula Álvarez-Huerta and Ainara Imaz Aguirre examines the development of soft skills in dual higher education master's programmes. By comparing students from education and business, the study highlights both the potential and the differentiated nature of competence development in work-integrated learning contexts. It reminds us that communication, social competence, flexibility, efficacy beliefs, and lifelong learning do not develop automatically. They require intentional pedagogical design, reflective structures, and sensitivity to disciplinary contexts.

The contribution by Ernst Deuer, Thomas Meyer and Kristina Smilyanska turns attention to the quality of practical training phases in dual study programmes. Drawing on long-term student survey data from Germany, the article offers important insights into how students perceive supervision, theory-practice integration, learning opportunities, and framework conditions during workplace phases. The findings underline a central point for the future of dual higher education: the workplace does not become a learning space by itself. It becomes educationally powerful when it is supported by quality, guidance, reflection, and cooperation.

Aisling Hurley's article expands the discussion towards strategic innovation, ethical leadership, and sustainability. By presenting the PBEE framework within work-integrated postgraduate learning, the paper demonstrates how design-led pedagogical scaffolds can support learners in addressing complex organisational and societal challenges. This contribution is particularly relevant because it positions dual higher education as a space for responsible innovation, systems thinking, and transformative capability development.

The article by Michel Bakni and Anna Dupouy provides a valuable country-focused perspective on dual higher education in Denmark. By analysing legal frameworks, applications, and educational pathways, the contribution enriches our understanding of the institutional diversity of dual higher education in Europe. It shows why comparative legal and structural analyses are essential for developing a European knowledge base: without understanding the diversity of systems, we cannot build meaningful common frameworks.

Maite Couto-Ortega, Leire Markuerkiaga and Laida San Sebastian explore the role of dual education programmes in smart specialisation strategies, focusing on Mondragon Unibertsitatea's Faculty of Engineering. Their contribution connects dual higher education with regional innovation, industrial transformation, and strategic development. It illustrates how dual education can act as a bridge between universities, companies, regional ecosystems, and long-term innovation agendas.

Finally, László Péter Juhász contributes a bibliometric analysis of the global intellectual structure of dual and work-integrated higher education. This article is particularly important for the journal's broader mission: it helps map the research field, identify knowledge clusters, and make visible how dual and work-integrated higher education has developed as an international scholarly domain. A field can only mature when it understands its own intellectual structure.

Taken together, the articles in this issue point to a larger agenda. We need research that does not merely ask whether dual higher education "works", but asks how, why, under which conditions, for whom, and with what societal consequences. We need studies that examine learning outcomes, quality conditions, institutional models, regional partnerships, student agency, inclusion, sustainability, digital transformation, and the changing relationship between universities and society. We need comparative research that respects diversity while enabling shared European

understanding. And we need conceptual work that helps us imagine higher education beyond the boundaries of the traditional campus.

The next generation of universities will not be defined by buildings, disciplines, or institutional routines alone. It will be defined by its capacity to connect knowledge with action, learning with responsibility, research with transformation, and students with the real challenges of society. Dual higher education offers one of the most powerful models for this rethinking. It is not the only answer to the future of higher education, but it is one of the most concrete and promising ones.

In this sense, the work of this journal is also a contribution to a new idea of the university: a university that is academically rigorous and socially embedded; research-based and practice-connected; European in outlook and locally engaged; committed to knowledge and to responsibility. A university that does not stand outside society, but learns with society, researches with society, and prepares students to shape society.

As Chief Editor, I would like to thank all authors for their valuable contributions, the reviewers for their careful and constructive work, and the editorial team for their dedication in developing this journal further. Scholarly journals are communities of practice and inquiry. They depend on intellectual generosity, critical dialogue, and a shared commitment to quality. This issue is a strong expression of that commitment.

I hope that the articles collected here will inspire researchers, educators, institutional leaders, policymakers, and practitioners to continue advancing dual higher education as a European field of research, innovation, and transformation.

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European Scientific Journal for Dual Higher Education

Vol. 2, No. 1, (2026)
ISSN (online): 3052-7015

DEVELOPING SOFT SKILLS THROUGH DUAL HIGHER EDUCATION: A COMPARISON OF EDUCATION AND BUSINESS MASTER'S STUDENTS

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Keywords:
Soft skills
Dual higher education
Pre-service teachers
Business education

Article history:
Received: 12 January 2026
Revised: 6 April 2026
Accepted: 20 May 2026

Abstract

This exploratory study examines changes in selected soft skills among master's students participating in Dual Higher Education (DHE) programmes and investigates whether these changes differ between fields of education and business. Using a pre–post design, data were collected from a convenience sample of 17 students enrolled DHE master's programmes in education and business. Students completed a questionnaire before and after participating in the programme, and repeated-measures analysis of variance was conducted to analyse changes over time, differences between fields of study, and interaction effects. The results indicated a significant improvement over time in oral and written communication skills, with a medium-to-large effect size. Education students reported consistently higher efficacy beliefs than business students at both measurement points, suggesting stable field-related differences. In addition, a significant interaction between time and field of study was found for social competence, with education students scoring higher than business students at post-test. These findings suggest that DHE master's programmes may effectively support the development of communication skills, while other soft skills appear to be shaped by disciplinary context and prior experiences. This underscores the need for discipline-sensitive and pedagogically intentional programme design.

1 Introduction

Ongoing societal transformations, including digitalisation, climate change, and rapid advances in artificial intelligence, are reshaping how individuals live, work, and learn (OECD, 2019). These changes have increased the demand for graduates who are not only technically competent but also able to respond effectively to uncertainty, complexity, and continuous change across professional and personal contexts (Sala et al., 2020).

European higher education policy has increasingly emphasised the role of universities in fostering these skills. In particular, the Bologna Process highlighted the responsibility of higher education institutions (HEIs) to support the development of transversal competences alongside academic knowledge (Sin & Neave, 2016). Soft skills are now widely recognised as higher-order capabilities that contribute to graduates' professional identity and work readiness, rather than as secondary or optional learning outcomes (Clarke, 2017). Nevertheless, despite sustained

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institutional efforts (Succi & Canovi, 2020), skills shortages remain across Europe (Chinn et al., 2020).

One approach that has gained increasing attention for supporting soft skill development is the integration of workplace learning into higher education programmes. Collaboration between HEIs and external organisations has been linked to improved skill acquisition and greater alignment between education and labour market needs (Arranz et al., 2022; Ferrández-Berrueco, 2016). In line with this perspective, research has shown that engaging in paid work alongside academic studies can contribute positively to students' soft skill development, particularly by exposing them to authentic professional demands and social interactions (Bennett et al., 2023).

Within this context, educational models that formally combine academic study with structured workplace experience are gaining increasing relevance. Dual Higher Education (DHE) programmes integrate university curricula with supervised periods of professional practice in qualified organisations, enabling students to apply theoretical knowledge to real-world tasks and challenges (Climent-Ferrando et al., 2024; Pogatsnik, 2018; Turk, 2023). Such initiatives are often discussed alongside related approaches, including Work-Based Learning (WBL) and Work-Integrated Learning (WIL), which similarly aim to connect higher education with workplace experience, although their terminology, structure, and degree of curricular integration vary considerably across national and institutional contexts (Ferns et al., 2024; Lester & Costley, 2010; Pogatsnik, 2018; Varga & Sági, 2024). Across Europe, a growing number of universities are implementing, expanding, or consolidating DHE programmes within their degree offerings, reflecting broader policy and institutional interest in work-integrated forms of higher education (Dragan & Hochrinner, 2024; Dupouy & Bakni, 2024a; Dupouy & Bakni, 2024b; Viklund & Elgundi, 2024).

DHE programmes differ from traditional internships in that they are embedded within the curriculum, involve systematic coordination between universities and workplaces, and often include enhanced tutoring and assessment mechanisms (Climent-Ferrando et al., 2024). Beyond facilitating the integration of theory and practice, DHE programmes are widely perceived as valuable for the development of soft skills because they encourage students to enact discipline-specific knowledge, behaviours, and professional competences in authentic work environments (Clarke, 2017; Tuononen et al., 2022). Across Europe, such programmes are increasingly being implemented at both bachelor's and master's levels. Although these programmes are perceived as beneficial for employability and professional development, empirical evidence on their effectiveness in fostering different soft skills remains limited, especially in master's degree programmes (Urkia-Basterra et al., 2025).

2 Theoretical framework

Soft skills are widely recognised as essential components of professional competence, yet their conceptualisation remains diverse and, at times, inconsistent. Terms such as soft skills, generic skills, and transversal competences are often used interchangeably, reflecting differing theoretical traditions and research contexts (Cinque, 2016; Marin-Zapata et al., 2022). To provide conceptual clarity, the present study is informed by the OECD Future of Education and Skills 2030 framework, which defines skills as the capacity to mobilise knowledge, attitudes, and values in order to act effectively and responsibly in complex situations (OECD, 2019). The study also adopts the Robles' definition of soft skills as interpersonal and career-related skills (Robles, 2012). This perspective emphasises that skills are demonstrated through action and are shaped by learning opportunities within specific social and professional contexts. In this study, the terms skills and competences are used in a complementary manner. Following the OECD framework, competences are understood as broader capabilities that integrating knowledge, skills, attitudes, and values, whereas soft skills refer to specific interpersonal and self-regulatory abilities enacted within professional contexts. The present study focuses on measurable soft skills as observable components of broader professional competences.

Several learning theories provide a rationale for expecting DHE and other work-based programmes to influence the development of these competences (Ferns et al., 2024). Experiential learning theory conceptualises learning as a cyclical process in which concrete experiences are

transformed into knowledge through reflection, abstraction, and experimentation (Kolb, 1984). The alternating structure of DHE programmes, in which students move repeatedly between academic and workplace environments, offers opportunities to engage in these cycles and to refine behaviour through practice. From a sociocultural perspective, learning is understood as inherently social and situated within specific communities of practice (Lave & Wenger, 1991; Vygotsky, 1978). Through participation in workplace activities and interaction with supervisors, colleagues, and clients, students are able to observe, model, and internalise professional norms and behaviours.

Although higher education primarily offers structured and formalised learning environments, workplaces provide rich opportunities for informal and unplanned learning experiences (Eraut, 2004). Learning that occurs in professional contexts enables individuals to expand and refine their knowledge, skills, and attitudes through everyday practice and interaction (Janssens et al., 2017). Such learning processes emphasise the importance of peer exchange and experiential engagement and support the development of a wide range of competences, including personal growth and collaborative abilities (Eraut, 2004). In this regard, research highlights that combining employment with academic study can be particularly beneficial for enhancing career awareness, social competences, and broader professional skills (Brosnan et al., 2024; Clark et al., 2015).

While DHE programmes provide a shared structural framework, the nature of learning opportunities and the importance of soft skills may vary across disciplinary contexts. In education, teaching practice is shaped not only by subject knowledge and cognitive skills but also by interpersonal abilities, beliefs, motivation, and the capacity to engage productively with diverse stakeholders (Hakkinen et al., 2020). For students preparing to enter the teaching profession, soft skills form a crucial component of professional preparedness and qualification (Yurt, 2023). Education placements typically emphasise interpersonal and pedagogical communication, whereas business placements may focus more on organisational communication, teamwork, and adaptability in dynamic settings. In business areas, contemporary workplaces place particular value on soft skills that encourage initiative, collaboration, and engagement with complexity (Fletcher & Thornton, 2023). These contextual differences may influence which soft skills are most frequently enacted and how feedback is provided, leading to potential variation in developmental patterns between fields of study.

Effective communication plays a central role in broader societal functioning and collaborative performance in professional settings (Marlow et al., 2018; OECD, 2021). Within DHE and WIL contexts, communication skills are among the most frequently examined competences, with evidence across multiple disciplines indicating that DHE programmes are perceived as supportive environments for their development (Urkia-Basterra et al., 2025). Nevertheless, despite their recognised importance, communication skills remain an area in which many students continue to demonstrate limitations (Moore & Morton, 2017).

Learning in workplace contexts is inherently social and experiential, offering opportunities for students to develop competences through interaction and participation in shared practices (Leiß & Rausch, 2023). The quality of students' interactions with peers, supervisors, and other professionals is closely related to their cognitive and behavioural development, highlighting the relevance of social competences in professional learning environments (Tan et al., 2022). Although social skills are often addressed under constructs such as teamwork or interpersonal competence, stakeholders continue to report gaps in students' social competences, underscoring the need for further investigation in this area (Prikshat et al., 2019).

Flexibility has been identified as a key competence for coping with uncertainty and navigating rapidly changing workplace environments (OECD, 2019). Immersive DHE experiences have been associated with enhanced adaptability, as students are required to respond to evolving professional demands and unfamiliar situations (Gardner, 2017; Martín-Lara et al., 2019). However, many graduates continue to struggle to develop flexibility, and students often underestimate its importance compared to employers' expectations (Chinn et al., 2020; Succi & Canovi, 2020). This discrepancy suggests that the role of workplace-based learning in fostering flexibility warrants further empirical attention.

Efficacy beliefs constitute a key construct in higher education research and refer to students' perceptions of their capacity to make a meaningful difference in academic and professional contexts (Yorke & Knight, 2006). Grounded in Bandura's (1997) conception of self-efficacy as beliefs in one's

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ability to organise and execute actions to achieve desired outcomes, efficacy beliefs are particularly relevant in DHE programmes, where learning is closely tied to the performance of authentic professional tasks. While engagement in work-related and extracurricular activities has been shown to foster self-efficacy and career-related confidence (Bennett et al., 2023; Brosnan et al., 2024), the development of efficacy beliefs within structured DHE programmes remains comparatively underexplored (Urkia-Basterra et al., 2025).

Finally, lifelong learning has been linked to improved professional adaptation, performance, and long-term employability (Drewery et al., 2017). Developing lifelong learning orientations is also considered essential for students' well-being and sustained success in dynamic labour markets (Ferns et al., 2024). Despite its relevance, research examining lifelong learning within DHE contexts remains limited, indicating a need for further studies exploring how structured work-integrated programmes support this competence over time (Drewery et al., 2020).

In this context, the present study explores changes in specific soft skills among master's students engaged in DHE programmes using a pre-post design. The research targets students enrolled in education and business master's programmes. It aims to determine whether participation in the DHE programme is associated with changes in social competence, efficacy beliefs, flexibility, lifelong learning, and communication skills, and whether these changes vary by field of study.

3 The present study

This study draws on the competence-based framework proposed by Scoupe et al. (2023), which integrates insights from higher education and workplace learning research. This perspective is particularly relevant for the present research, as DHE programmes intentionally integrate academic study with professional practice. Their work proposes seven soft skills: social competence, e-literacy, efficacy beliefs, flexibility, healthy work-life balance, lifelong learning, and oral and written communication. Nevertheless, while Scoupe et al. (2023) include e-literacy and work–life balance within their framework, these dimensions were not considered in the present study. In DHE programmes, digital competences are typically embedded within academic and workplace activities, while programme structures are less directly associated with students' work-life balance. Consequently, this study focuses on five soft skills: social competence, oral and written communication, flexibility, efficacy beliefs, and lifelong learning.

Within this framework, social competence refers to the ability to establish and maintain professional relationships and collaborate effectively with others. Efficacy beliefs reflect individuals' confidence in their capacity to perform tasks and manage learning processes within their field. The SECQ efficacy beliefs subscale operationalises self-efficacy as domain-specific, employability-related confidence, consistent with Bandura's (1997) conceptualisation of efficacy beliefs as context-bound perceptions of capability. Flexibility involves adapting to changing demands and students' capacity to control their emotions when responding to unexpected situations. Lifelong learning represents an ongoing orientation towards personal and professional development, including career planning and skill renewal. Communication encompasses oral and written abilities required to convey ideas clearly across diverse settings.

Empirical studies examining DHE as a distinct form of WIL remain limited, especially at the master's level. While DHE can be understood as a specific institutionalised form of WIL, the present study focuses on DHE due to its structured alternation and formal partnership model. Furthermore, existing research has tended to focus on selected skills or specific disciplinary contexts, leaving gaps in understanding how different soft skills develop over time and whether such development varies across fields of study (Urkia-Basterra et al., 2025).

Therefore, the present study examines changes in these soft skills among master's students participating in a DHE programme. Using a pre-post design, the study investigates whether participation in the DHE programme is associated with changes in these five soft skills. In addition, the study compares students enrolled in education and business master's programmes in order to explore whether patterns of soft skill development differ by field of study. Given the limited empirical evidence on soft skill development within DHE master's programmes, particularly across disciplinary

contexts, this study adopts an exploratory approach. The findings are therefore intended to provide initial insights rather than definitive conclusions.

The following research questions were formulated:

- RQ1: Are there observable changes in students' soft skills over the course of participation in the DHE programme?
- RQ2: Are there any significant differences between the fields of study?

4 Methodology

4.1 Participants

The sample consisted of 17 students enrolled in master's degree programmes related to educational sciences and business at a university in the Basque Country, northern Spain. Of the 17 students, seven were enrolled in an educational sciences degree and ten in various business-related degrees. Given the exploratory nature of the study and the emerging implementation of DHE at the master's level, the sample size reflects an initial cohort rather than a representative population.

The participants were enrolled in DHE master's programmes offered by a university in the Basque Country, northern Spain. These programmes follow a structured alternation model in which academic coursework is formally integrated with supervised professional practice in partner organisations throughout the academic year. Although both groups were enrolled in DHE master's programmes, the organisation of university-workplace alternation differed by field of study. Students in education-related programmes alternated short, recurring periods of school-based practice with periods of university coursework throughout the academic year. In contrast, students in business-related programmes followed a daily alternation model, typically combining workplace and university activities within the same day, most commonly through morning-afternoon arrangements. In terms of total workplace hours, master's students in both fields completed approximately 700 to 800 hours of work.

4.2 Instruments

All five soft skills - social competences, efficacy beliefs, flexibility, lifelong learning, and oral and written communication - were measured using the SECQ Questionnaire (Scoupe et al., 2023). All items were measured on a five-point Likert-type scale, ranging from 1 = "Completely disagree" to 5 = "Completely agree".

Table 1. Questionnaire structure and reliability analysis

Soft skill	*Pre Cronbach's α*	*Post Cronbach's α*	*Item number*	*Example*
Social competences	0.78	0.84	6	I can operate within and contribute to a respectful, supportive, and cooperative group climate.
Efficacy beliefs	0.81	0.73	8	I feel confident and ready to start working.
Flexibility	0.59	0.78	4	In my field of expertise, I consider myself competent to add value by embracing new ideas and demonstrating creativity in addressing challenges and problems.
Lifelong learning	0.57	0.64	4	I am focused on continuously developing myself.
Oral and written communication	0.80	0.82	5	I clearly express my thoughts and opinions in writing.

The lifelong learning subscale of the SECQ Questionnaire (Scoupe et al., 2023) originally included six items. The initial six-item lifelong learning subscale demonstrated low internal consistency at post-test (α = .41). Inspection of item-total correlations indicated that two reverse-coded items contributed negatively to reliability. Reverse-coded items are known to introduce method effects and misunderstanding, particularly in translated or self-report educational measures. Therefore, these two items were removed to improve internal consistency and ensure more coherent measurement of the construct. Although removal of the reverse-coded items improved internal consistency, this decision may have implications for construct breadth. The revised subscale may emphasise positively framed aspects of lifelong learning orientation while potentially underrepresenting dimensions such as resistance or ambivalence towards learning that were reflected in the reverse-coded items. Therefore, the findings should be interpreted in light of this modification.

4.3 Procedure

Participants were recruited using convenience sampling. Before participation, students were informed about the purpose of the study and assured that participation was entirely voluntary and that all responses would remain confidential. The pre-test was administered in September before the start of the programme, and the post-test was administered after the programme in May-June. Electronic informed consent was obtained from all students before data collection. Completion of the survey took approximately 10 minutes. The study protocol received approval from the university's Ethics Committee for Research Involving Human Subjects.

4.4 Data analysis

Data were analysed using repeated-measures analysis of variance (ANOVA). Time (pre-test vs. post-test) was treated as a within-subjects factor, while field of study was included as a between-subjects factor. This approach enabled the examination of changes in students' soft skills over time, differences between fields, and the interaction between time and field.

The choice of repeated-measures ANOVA reflects the longitudinal structure of the data and the study's interest in both within-subject change and between-group differences. By modelling time as a within-subjects factor and field of study as a between-subjects factor, this approach enabled the simultaneous examination of developmental trajectories and disciplinary variation. Given the relatively small sample size, effect sizes were considered particularly important for interpretation. Partial eta-squared values provide information about the magnitude of observed effects and offer insight into practical significance beyond p-values alone.

A small amount of missing data was observed, primarily affecting some pre-test responses among business students. Analyses in JAMOVI were conducted using listwise deletion for repeated-measures ANOVA; therefore, only participants with complete data for the variables included in each model were retained. Given the exploratory nature and small sample size, no imputation procedures were performed.

Before analysis, assumptions of repeated-measures ANOVA were evaluated. All variables showed adequate skewness and kurtosis values (skewness range: -0.98 to 0.66; kurtosis range: -1.60 to 1.73), which were considered acceptable for normality. Effect sizes were reported using partial eta squared (η^2p). Statistical significance was set at $p < .05$. All analyses were conducted using JAMOVI version 2.6.26.0.

5 Results

Table 2 presents the descriptive statistics for all soft skills measured before (pre-test) and after (post-test) participation in the DHE programme. Overall, mean scores were relatively high at baseline across all dimensions. Small changes between pre- and post-test means were observed, with some skills showing slight increases and others remaining stable or slightly decreasing. Specifically, flexibility increased from a pre-test mean of 3.81 (SD = 0.41) to a post-test mean of 4.00 (SD = 0.49),

while communication increased from 3.88 (SD = 0.53) to 4.04 (SD = 0.58). In contrast, social competence showed a minimal decrease from 4.47 (SD = 0.38) to 4.42 (SD = 0.46). Similarly small decreases were observed for efficacy beliefs and lifelong learning. Descriptive statistics (Table 2) revealed high baseline means across all measured constructs, with social competence approaching the upper end of the scale, indicating limited variability at pre-test.

Table 2. Descriptive statistics

	Mean	*Median*	*SD*	*Min*	*Max*
pre_sc	4.47	4.40	0.380	3.80	5.00
post_sc	4.42	4.40	0.462	3.60	5.00
pre_eb	3.98	3.88	0.510	2.63	4.75
post_eb	3.84	3.75	0.528	3.00	4.88
pre_flx	3.81	3.75	0.410	3.00	4.75
post_flx	4.00	4.00	0.489	3.25	5.00
pre_ll	3.74	3.75	0.480	2.50	5.00
post_ll	3.71	3.63	0.611	2.50	5.00
pre_com	3.88	3.80	0.525	3.20	5.00
post_com	4.04	4.00	0.578	2.80	5.00

Results from repeated-measures ANOVA (Table 3) showed no significant overall change over time in social competence ($F = 0.176$, $p = 0.681$, $\eta^2p = 0.012$). However, a significant interaction between time and field of study emerged ($F = 5.639$, $p = 0.031$, $\eta^2p = 0.273$). Post hoc comparisons indicated that education and business students differed significantly at post-test, with education students scoring higher than business students (mean difference = 0.657, $p = 0.004$). No statistically significant differences between fields were observed at pre-test, and within-field pre-post comparisons did not reach significance. Descriptive statistics by field showed that education students' social competence increased from M = 4.60 (SD = 0.37) at pre-test to M = 4.86 (SD = 0.19) at post-test, whereas business students' scores decreased slightly from M = 4.38 (SD = 0.38) to M = 4.22 (SD = 0.44). Although these within-group changes were not statistically significant, the opposite directions of change resulted in a widening gap between fields at post-test, explaining the significant time × field interaction.

Scores for efficacy beliefs remained stable over time, with no significant main effect of time ($F = 0.012$, $p = .914$, $\eta^2p = 0.001$) and no significant time and field interaction ($F < 0.001$, $p = 0.985$, $\eta^2p < 0.001$). Nevertheless, a significant between-subjects effect of field was found ($F = 7.02$, $p = 0.018$, $\eta^2p = 0.319$). Post hoc comparisons showed that education students reported higher efficacy beliefs than business students overall (mean difference = 0.490, $p = 0.018$).

A tendency towards improvement was observed in flexibility. Although this effect did not reach statistical significance, it showed a small-to-medium effect size ($F = 3.631$, $p = 0.076$, $\eta^2p = 0.195$). Neither the interaction between time and field ($F = 0.048$, $p = 0.829$, $\eta^2p = 0.003$), nor the between-subjects effect of field ($F = 0.278$, $p = 0.606$, $\eta^2p = 0.018$) reached statistical significance. Given the absence of significant effects, post hoc analyses were not interpreted.

No significant changes over time were detected in lifelong learning, with a non-significant main effect of time ($F = 0.005$, $p = 0.947$, $\eta^2p < 0.001$), and no significant interaction between time and field ($F = 0.147$, $p = 0.707$, $\eta^2p = 0.010$). Differences between fields of study were also not statistically significant ($F = 2.88$, $p = 0.110$, $\eta^2p = 0.161$), and no post hoc tests indicated meaningful pairwise differences.

A significant improvement over time was observed in communication, as shown by a significant main effect of time ($F = 6.783$, $p = 0.020$, $\eta^2p = 0.311$). Post hoc comparisons confirmed that communication scores were significantly higher at post-test than at pre-test (mean difference = -0.324, $p = 0.020$). Neither the interaction between time and field ($F= 0.701$, $p = 0.415$, $\eta^2p =$

0.045), nor the between-subjects effect of field (F = 3.12, p = 0.098, η^2p = 0.172), reached statistical significance, indicating that this improvement was consistent across fields of study.

Table 3. Effects of the DHE programme and field of study

		F	*Mean Square*	*p*	*η^2p*
Social competence	Time	0.176	0.012	0.681	0.012
	Time * field	5.639	0.393	0.031*	0.273
Efficacy beliefs	Time	0.012	0.002	0.914	0.001
	Time * field	3.76e–4	5.91e–5	0.985	0.000
Flexibility	Time	3.631	0.335	0.076	0.195
	Time * field	0.048	0.004	0.829	0.003
Lifelong learning	Time	0.005	9.45e–4	0.947	0.000
	Time * field	0.147	0.030	0.707	0.010
Communication	Time	6.783	0.866	0.020*	0.311
	Time * field	0.701	0.090	0.415	0.045

6 Discussion

The present study examined changes in selected soft skills among master's students participating in DHE programmes and explored whether these changes differed between education and business students. Overall, the findings provide a nuanced picture of soft skill development in DHE contexts, suggesting that participation in the programme is associated with improvement in specific competences, not all soft skills evolve uniformly over time or develop identically across fields of study.

This nuanced pattern reinforces perspectives that conceptualise soft skills as contextually situated and unevenly developed, rather than as a homogeneous set of outcomes. In DHE environments, students are exposed to multiple, and sometimes competing, expectations that may stimulate growth in some skills while stabilising others. Consequently, the absence of uniform change across all measured skills should not be interpreted as a weakness of DHE programmes, but rather as an indication of the differentiated nature of learning processes embedded within professional practice.

With regard to RQ1, the results indicate that oral and written communication skills increased significantly from pre-test to post-test during the programme period. Communication was the only soft skill showing a statistically significant main effect of time, with a medium-to-large effect size. This finding aligns with experiential and sociocultural learning perspectives (Kolb, 1984; Lave & Wenger, 1991), which emphasise that repeated engagement in authentic professional situations fosters the development of skills that are enacted through practice. DHE programmes require students to communicate regularly with supervisors, colleagues, and academic tutors, as well as to

adapt their discourse to different audiences and contexts. Such sustained exposure may explain why communication skills appear particularly responsitive to development through DHE.

In addition, communication spans both academic and professional environments, making it consistently important throughout the DHE experience. Students must engage in written reporting, oral presentations, professional correspondence, and informal interaction, all of which provide frequent opportunities for feedback and self-regulation. These repeated communicative demands may accelerate the development of communication skills more effectively than skills that are enacted less explicitly or evaluated less directly. This finding is in line with previous research indicating that WIL programmes are effective for developing communication skills (Doolan et al., 2019; Fleming & Haigh, 2017; Grooters et al., 2023).

In contrast, no significant overall changes were observed for social competence, efficacy beliefs, flexibility, or lifelong learning. One plausible explanation relates to the relatively high baseline scores observed at pre-test, suggesting potential ceiling effects. Students entering DHE master's programmes may already possess well-developed soft skills due to prior academic and professional experiences, limiting the observable magnitude of change.

Nevertheless, flexibility showed a tendency towards improvement, with a medium effect size despite not reaching conventional levels of statistical significance. Given the small sample size, this trend may still be theoretically meaningful. Flexibility is closely linked to coping with uncertainty and adapting to changing demands (OECD, 2019), which are core features of alternating academic and work environments. From an experiential learning perspective, such competences are expected to develop through repeated cycles of action, reflection, and adjustment (Kolb, 1984). It is possible that flexibility may develop gradually as students accumulate diverse experiences across placements, suggesting that longer or more intensive DHE trajectories might yield clearer effects. This interpretation aligns with theoretical accounts that position flexibility as a skill shaped through exposure to complex and unpredictable situations, as well as with previous research indicating that adaptability can be developed in WIL contexts (Gardner, 2017; Martín-Lara et al., 2019). In DHE contexts, students must frequently negotiate transitions between institutional settings, manage competing deadlines, and respond to evolving workplace expectations. Such experiences may initiate developmental processes that are not immediately captured through quantitative measures but contribute to longer-term professional adaptability.

Regarding RQ2, differences between fields of study emerged for efficacy beliefs. Education students reported significantly higher efficacy beliefs than business students at both measurement points, indicating a field-related difference rather than an effect of participation in the DHE programme. This pattern may suggest that efficacy beliefs are strongly influenced by disciplinary and professional socialisation processes. The higher efficacy beliefs among education students may be attributable to educational pathways that typically emphasise clearly defined professional roles, normative standards of practice, and ongoing formative feedback, all of which support the development of self-efficacy through repeated mastery and social persuasion experiences (Bandura, 1997; Dacre Pool & Sewell, 2007). From a sociocultural perspective, efficacy beliefs are shaped not only by successful task completion but also by how achievement is interpreted and valued within specific professional communities. Research in teacher education has previously shown that strong efficacy beliefs are associated with professional commitment and motivation, personal accomplishment, resilience, and well-being, reinforcing their centrality in educational contexts (Pendergast et al., 2011; Zee & Koomen, 2016).

A significant interaction between time and field was observed for social competence. Although no overall change over time was detected, education students scored significantly higher than business students at the post-test. This divergence suggests that the DHE experience may differentially shape social competence depending on disciplinary context. Education placements typically involve sustained interpersonal interaction with pupils, colleagues, and families, as well as continuous relational and emotional engagement, which may provide richer opportunities to enact and refine social competences. In contrast, business placements may prioritise task-oriented collaboration and performance outcomes over explicitly relational processes.

Taken together, the findings suggest that DHE programmes may not uniformly enhance all soft skills, but they appear particularly relevant for fostering communication skills and, to a lesser extent, flexibility and social competence in context-specific ways. These findings suggest that soft skill

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development may be highly situated and contingent on the nature of learning opportunities embedded within specific disciplinary and professional environments.

6.1 Implications

The findings of this study offer several practical implications for the design, implementation, and evaluation of DHE programmes at the master's level. However, given the exploratory design, small sample size, and absence of a control group, these implications should be interpreted cautiously and regarded as indicative rather than prescriptive. First, the significant improvement observed in oral and written communication suggests the value of sustained engagement in authentic professional contexts for developing skills that are enacted frequently across both academic and workplace settings. Universities and partner organisations might therefore consider embedding structured communication opportunities within DHE curricula, such as reflective reporting, professional writing tasks, presentations, and regular feedback exchanges with workplace tutors. These activities appear particularly effective when communication demands are explicit and aligned across institutional contexts (Clarke, 2017; Urkia-Basterra et al., 2025).

Second, the absence of significant change in several soft skills, despite medium effect sizes in some cases, suggests that not all competences develop automatically through participation in DHE programmes. Skills such as lifelong learning, flexibility, and efficacy beliefs may require more intentional pedagogical scaffolding. Programme designers could strengthen these dimensions by incorporating guided reflection, mentoring conversations, and goal-setting activities that encourage students to articulate learning strategies, manage uncertainty, and recognise competence development over time (Ferns et al., 2024). Such measures may be particularly important at the master's level, where students often enter programmes with relatively high baseline skills and may benefit more from refinement than from exposure alone.

Third, the field-specific patterns identified in social competence and efficacy beliefs highlight the potential importance of discipline-sensitive programme design. DHE initiatives should acknowledge that professional socialisation processes differ between education and business contexts and that soft skills are enacted and reinforced in field-specific ways (Fletcher & Thornton, 2023). Closer coordination between academic staff and workplace supervisors could support alignment between expected learning outcomes and the actual opportunities provided in placements, ensuring that less visible competences are recognised and intentionally supported.

Overall, these findings suggest that while DHE programmes may offer opportunities for soft skill development, their full potential may be enhanced when experiential learning is complemented by structured pedagogical support that accounts for disciplinary context and students' developmental stage.

7 Limitations and further research

Several limitations should be considered when interpreting these findings. The small sample size reflects the limited scale and emerging status of DHE master's programmes and constrains statistical power and generalisability. Significant interactions in studies with small samples should also be interpreted with caution. However, exploratory designs are particularly valuable in under-researched contexts, as they allow for the identification of patterns, effect sizes, and theoretically meaningful tendencies that can inform future large-scale and comparative studies. Some non-significant findings, particularly those with medium effect sizes, may reflect insufficient power rather than the absence of meaningful effects. The study also relied exclusively on self-report measures, which may be influenced by social desirability or students' subjective interpretations of their skills. Future research could incorporate supervisor assessments, peer evaluations, or performance-based measures to triangulate findings.

Additionally, baseline scores were notably high across several scales, especially in social competence, which nearly reached the upper limit of the response range. Such restricted variance reduces the sensitivity of the measures to detect change over time and may attenuate growth estimates. When participants begin near the maximum of a scale, further development cannot be

adequately captured, even if real improvements occur. Consequently, the observed stability in some domains may partly reflect measurement limitations rather than true developmental stagnation.

The absence of a control group prevents causal conclusions about the effects of DHE participation. Longitudinal designs, including comparison groups enrolled in traditional master's programmes, would strengthen causal inference. In addition, longer follow-up periods may be necessary to capture the development of more stable or dispositional skills such as lifelong learning and efficacy beliefs.

Moreover, the finding of higher efficacy beliefs observed among education students reflects enduring disciplinary cultures rather than differential benefits of the DHE programme itself. This highlights the need for further research on how DHE structures may more intentionally support the development of efficacy beliefs across fields. Similarly, research on contextual and interactional factors across distinct fields and DHE programmes may provide insight into the elements that support or hinder social competences. Finally, qualitative approaches could provide deeper insight into how specific features of workplace placements contribute to the development of different soft skills across disciplinary contexts.

8 Conclusion

This study contributes to the emerging empirical literature on DHE by examining changes in multiple soft skills among master's students in the fields of education and business. The findings indicate that DHE participation is associated with significant improvement in communication skills and field-specific patterns in social competence. At the same time, several soft skills remained stable over the programme period, highlighting the complexity of soft skill development and the influence of prior experiences and contextual factors. As an exploratory study, these findings should be understood as indicative rather than conclusive, offering a foundation for further empirical research on DHE master's programmes.

Overall, the results suggest that DHE programmes offer valuable opportunities to develop certain soft skills, particularly those closely tied to active participation in professional practice. However, they also suggest that intentional pedagogical design and targeted support may help promote broader and more consistent soft skill development across disciplines.

Acknowledgement

This study received funding from the Basque Government IKERHEZI-IT1664-22. In addition, the first author acknowledges financial support in the form of a pre-doctoral grant awarded by the Faculty of Humanities and Education of Mondragon Unibertsitatea (Grant No.: MU-HUHEZI-2303).

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European Scientific Journal for Dual Higher Education

Vol. 2, No. 1, (2026)
ISSN (online): 3052-7015

QUALITY OF PRACTICAL TRAINING PHASES AS A PART OF DUAL STUDY PROGRAMMES FROM THE STUDENTS' PERSPECTIVE – RESULTS OF A LONG-TERM STUDY FROM GERMANY

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Keywords:
Quality of practical training
Student satisfaction
Assessment of dual study programmes
Theory-practice integration

Article history:
Received: 23 December 2025
Revised: 4 February 2026
Accepted: 22 May 2026

Abstract

The practical training phases in cooperating companies and institutions are an important part of dual study programmes, enabling students to develop professional knowledge and skills. The quality of these phases and their influence on student satisfaction have been examined repeatedly in annual student surveys at Baden-Wuerttemberg Cooperative State University (DHBW). The surveys analysed quality aspects and their correlations with satisfaction with the dual study programme. Current findings show clear differences between fields of study: students from technical and economics programmes rate the practical phases more positively than students from social work and health programmes. Across all fields, the integration of theory and practice is rated comparatively negatively, while professional training and integration into operational processes are rated particularly positively. High-quality supervision and intensive support are identified as key factors associated with satisfaction. Professional fit, knowledge transfer, and collegial exchange show strong correlations with satisfaction, whereas material conditions and time management are less influential. Students who are dissatisfied with the quality of practical training are more likely to consider changing or dropping out, whereas satisfied students more often plan to work for their training company in the long term. Overall, the results highlight the importance of intensive support, improved integration of theory and practice, and the creation of learning spaces for increasing satisfaction and retaining students in the long term.

1 Introduction

In dual study programmes, practical training phases within cooperating companies and institutions are a central element of the curriculum. In this learning setting, students should not only acquire subject-specific knowledge but also develop operational experience and job-related skills. At the same time, the university, as the quality assurance authority, is responsible for ensuring that the learning topics covered in the practical training phases correspond to the requirements of an

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academic degree programme and that the tasks appropriately complement the theoretical learning content (Arens-Fischer & Dinkelborg 2020; DGB Bundesvorstand 2019). The practical tasks and activities must therefore be appropriate to academic learning in terms of content and didactics and must complement it in a meaningful way (Gerstung-Jungherr & Deuer 2025a).

For these reasons, the quality of practical training phases should be examined systematically. Student surveys are a useful tool for examining how dual students evaluate various aspects of their practical training phases. Using student surveys conducted as part of a long-term study at Baden-Württemberg Cooperative State University (DHBW), this article examines how students rate various quality indicators. The research project entitled "Academic progress in a dual study programme - important steps, criteria for success, and obstacles during studies at DHBW" has now been running for 10 years and students' assessment of the quality of practical training have already been examined in several survey waves (Deuer & Meyer 2024, Deuer & Meyer 2020, further information at www.dhbw.de/studie).

First, we examine how dual students evaluate their practical training phases in companies and to what extent their evaluations correspond to their general satisfaction with the practical training phases. In addition to satisfaction with the practical phases, it is relevant to examine the extent to which assessments of practical training quality are associated with other aspects of the study programme. Therefore, in a second step, we analyse whether there are correlations between evaluations of the practical training phases and general satisfaction with the dual study programme (e.g., intentions to switch study programmes, tendency to drop out). It is also relevant to examine whether evaluations of the quality of the practical phases are associated with willingness to work for the cooperating companies and institutions after graduation.

2 Theoretical framework and previous analyses of practical training quality in the DHBW long-term study

2.1 The central importance of practical training phases in dual study programmes

Dual study programmes have their roots in the German vocational training tradition, which is strongly influenced by the idea of combining theoretical knowledge and practical training. While the classic dual training system - a combination of work experience and vocational school - had long been internationally recognised as a successful model, dual study programmes emerged much later, in the 1970s. In Baden-Wuerttemberg, the first cooperative study programmes were founded at that time to give companies the opportunity to train qualified specialists and skilled workers in a practice-oriented manner (Deuer & Träger 2015). The business community was seeking an alternative to purely academic programmes, which were often perceived as insufficiently practice-oriented, while the demands placed on skilled workers were increasing. Dual study programmes were intended to close this gap.

Over time, the concept was further developed and expanded to other federal states in Germany. With the Bologna reform and the transition to bachelor's and master's degrees, some vocational academies were converted into state-recognised universities - a key step that upgraded the status of dual study programmes and made them more comparable nationally and internationally. Today, numerous universities and cooperating companies or institutions offer a wide range of dual study programmes, spanning technical and economic disciplines as well as social services, health, and media.

Dual study programmes are highly important for companies and society. For companies, they represent a strategic opportunity to attract well-trained young talent at an early stage, as these students are already familiar with the company's structures, processes, and values. Company loyalty is high, post-graduation training periods are short, and graduates possess a rare and attractive combination of scientific skills and practical experience (Arens-Fischer & Dinkelborg 2020; Arens-Fischer et al. 2016; Krone 2023). For students, dual study programmes offer a clear career focus, financial security through remuneration, and strong entry-level opportunities after graduation. In addition, dual study programmes strengthen Germany's competitiveness as a business location by offering a training system that bridges the gap between academia and industry. It forms an important

basis for innovation, technological progress, and securing qualified skilled workers - aspects that are becoming increasingly important in an international comparison. Thus, dual study programmes have developed from a regional model into a recognised educational pathway, both in Germany and internationally (Krone 2023; Ertl 2020; Wild & Alvarez 2020).

The practical training phases are a central part of the dual study programme curriculum. They are purposefully designed to combine the university learning environment with a systematic, practice-based workplace learning environment. The integration of these two learning areas is a fundamental structural principle of dual study programmes (Gerstung-Jungherr & Deuer 2025a; DGB-Jugend 2023; Krone 2023), and it is only through the planned integration of theory and practice that the special added value of this educational model emerges. In cooperating companies and institutions, students gain direct insight into work processes, organisational structures, and professional routines. This is not just about getting to know the activities involved, but about gradually growing into professional roles and areas of responsibility. The practical experience developed in this context is of central importance for later professional competence, as it extends far beyond theoretical knowledge: it includes situational judgement, communication and problem-solving skills, teamwork, and an understanding of institutional processes and decision-making procedures (Arens-Fischer & Dinkelborg 2020; Arens-Fischer et al. 2016).

At the same time, the university has overall responsibility as the quality assurance authority. It must ensure that the learning content addressed during the practical training phases meets the requirements of an academic degree programme. This means that the tasks assigned in the company cannot be arbitrary but must be linked to the theoretical content of the study programme in a meaningful way in terms of content and didactics. The practical phases should not replace the academic content, but rather supplement and deepen it, so that a coherent and scientifically based learning process emerges. As Gerstung-Jungherr and Deuer (2025a) emphasise, practical training activities must therefore be proportionate to academic requirements and meaningfully expand on them. Tasks that are too easy, purely administrative, or unrelated to the subject matter do not meet this requirement, nor do activities that would overwhelm students without a theoretical knowledge base (see also Arens-Fischer & Dinkelborg 2020; DGB-Jugend 2023, Krone 2023).

The university assumes a moderating role here: it defines learning objectives, supports practical training with reflection and transfer tasks, and regularly checks whether the practical training phases actually generate the intended educational added value. This establishes a dialogue between the company and the university, in which both sides contribute to the development of the students' skills. Overall, the practical phases are therefore not merely an organisational element but a pedagogically and didactically designed core component of the dual study programme. They enable students to acquire professional skills, facilitate close integration of theory and practice, and increase the quality and attractiveness of this study model. Furthermore, the interplay of knowledge- and practice-oriented activities helps students broaden their skills, which again demonstrates the importance of quality assurance at universities and companies (Arens-Fischer & Dinkelborg 2020; Arens-Fischer et al. 2016).

2.2 The challenge of measuring the quality of practical training phases

The construct of practical training quality has been repeatedly analysed in the annual student surveys conducted at DHBW over the past 10 years. Various item batteries were used, some of which were based on proven instruments. For the first time, student assessment of practical training quality was measured in the 2016 student survey using six items on the integration of theory and practice as a key indicator of practical quality (Deuer & Wild 2017). In the 2020 student survey, a more comprehensive inventory for the integration of theory and practice was developed by constructing three item batteries for each of the three dimensions: institutional integration, organisational integration, and content integration (Gerstung & Deuer 2021). However, since the concept of practical training quality encompasses not only the integration of theory and practice, but also other aspects such as social integration, the transparency of operational structures, the diversity of tasks, and the quality of supervision by those responsible in companies and institutions, the 2022 student survey ultimately used the "Mannheim Inventory for Recording Operational Training

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Situations" (MIZEBA) in a version adapted and further developed for dual study programmes (Hettler et al. 2022). Finally, in the 2024 student survey, an even more complex construct was operationalised, based on items from the IAQ student survey (Krone et al. 2019, Gerstung-Jungherr & Deuer 2025b). The questionnaire comprises four dimensions, which are presented in more detail in section 3 (see also Figure 1). The 2025 student survey also included additional questions on the operationalisation of the quality of supervision in practical training. These items are presented in section 4.

2.3 Correlations between students' assessments of practical training quality and satisfaction with the study programme, doubts or the tendency to drop out

In addition to the examination of students' ratings of various dimensions of practical training quality, it is also of interest if there are correlations between these ratings and satisfaction with the practical training phases. Furthermore, it is also of interest to see to what extent the perceived quality of practical training could also influence satisfaction with the whole dual study programme. This satisfaction can be operationalised, for example, with questions about the intention to change the course of study and/or the practical training location, or the tendency to drop out. This question will be explored in conclusion in this section.

Indications of the importance of practical training quality for overall satisfaction with the dual study programme have already been found in earlier data analyses of our long-term research project:

Rahn et al. (2020) analysed data from a survey of university dropouts at DHBW from different student cohorts (n=902; 2013-2017 cohorts) regarding their reasons for dropping out. Cluster analysis was used to identify three types of dropouts ("burdened," "overwhelmed," and "disappointed"). In addition, 11 dropouts were interviewed in qualitative depth interviews about their reasons for dropping out. The analysis shows that the dropouts were by no means only students who dropped out due to the level of demand and poor performance ("overwhelmed"). A significant proportion of the reasons for dropping out also related to various stress factors during their studies ("burdened") and dissatisfaction with the dual study programme and its framework conditions ("disappointed"). The latter group is interesting because these are students who achieved good grades in their studies. However, their dissatisfaction was only partly related to the university; in many cases, dissatisfaction with the company was a trigger for doubts about their studies and dropouts. For these students, the practical training phases were most frequently cited as the reason for dropping out in comparison to the other two groups. The qualitative case studies describe the example of a female student whose decision to drop out of university was influenced by insufficient support during her practical training and a lack of challenging tasks.

In an evaluation of data from the 2020 student survey (response rate: n=4,717), Rahn et al. (2022) analysed the relationship between students' perceptions of the quality of practical training and various items relating to satisfaction with their studies (e.g., satisfaction with the practical training placement, intentions to change the course of study and/or the practical training location, and tendency to drop out). The assessment of practical training quality was measured based on previous operationalisation attempts on the topics of theory-practice integration and quality of practical training phases from previous student surveys as part of the DHBW project (Deuer & Wild 2017; Gerstung & Deuer 2021a, 2021b). The integration of theory and practice, the quality of supervision and support for students in the practical training phases, and the competence of the supervisor were taken into account in a total of 15 individual items. These were combined into an index (practical training quality). Together with other variables relating to satisfaction with the course of study, a cluster analysis was then carried out. The result of which was two clusters that differed in terms of the perception of practical training quality, intentions to change practice location or study subject, and the tendency to drop out. The correlations found can be described as follows: the higher the perceived practical training quality, the lower the intention to change and the tendency to drop out. The authors were also able to show that dissatisfied students reported a lower work-life balance than satisfied (Rahn et al. 2022, p. 10ff.).

3 Methodology

This article presents findings from the DHBW research project concerning evaluations of practical training quality, with a focus on the 2024 student survey. Data from the 2024 survey were used to analyse students' assessments of practical training quality using German school grades across four dimensions (supervision and assistance, integration of theory and practice, practical tasks and learning opportunities, and framework conditions and networks). In addition, we examined the correlation between this assessment and satisfaction with the practical training phase. Finally, we also compared satisfied students with dissatisfied students in terms of doubts about their studies and their tendency to drop out. To reinforce the robustness of these findings, data from the 2025 student survey was additionally used to examine the differences between satisfied and dissatisfied students.

For our analyses, we used univariate, bivariate, and multivariate analysis methods. Univariate analyses were used to measure the practical training quality. Bivariate analyses were performed to investigate the relationship between the assessment of practice quality and satisfaction with the practice phases. Multivariate analyses were used to compare satisfied and dissatisfied students.

To analyse the students' evaluations of practical training quality, we used data from the 2024 online survey of bachelor's students. The survey was conducted in June and July 2024. A total of 29,768 bachelor's students (population) were invited to take part in the survey. A total of n=4,444 students started the questionnaire; of these, n=2,741 completed the survey in full. This represents a response rate of 9.2% of the population. The quality of the practical learning location was examined from the students' perspective (see also Hettler et al. 2022). The items used for this purpose were taken from the 2015 IAQ student survey (Krone et al. 2019), which represents a broad spectrum of relevant quality dimensions of the practical training phases (see also Gerstung-Jungherr & Deuer 2025b). A total of thirteen characteristics were considered, which can be assigned to a framework model with four categories (see Figure 1).

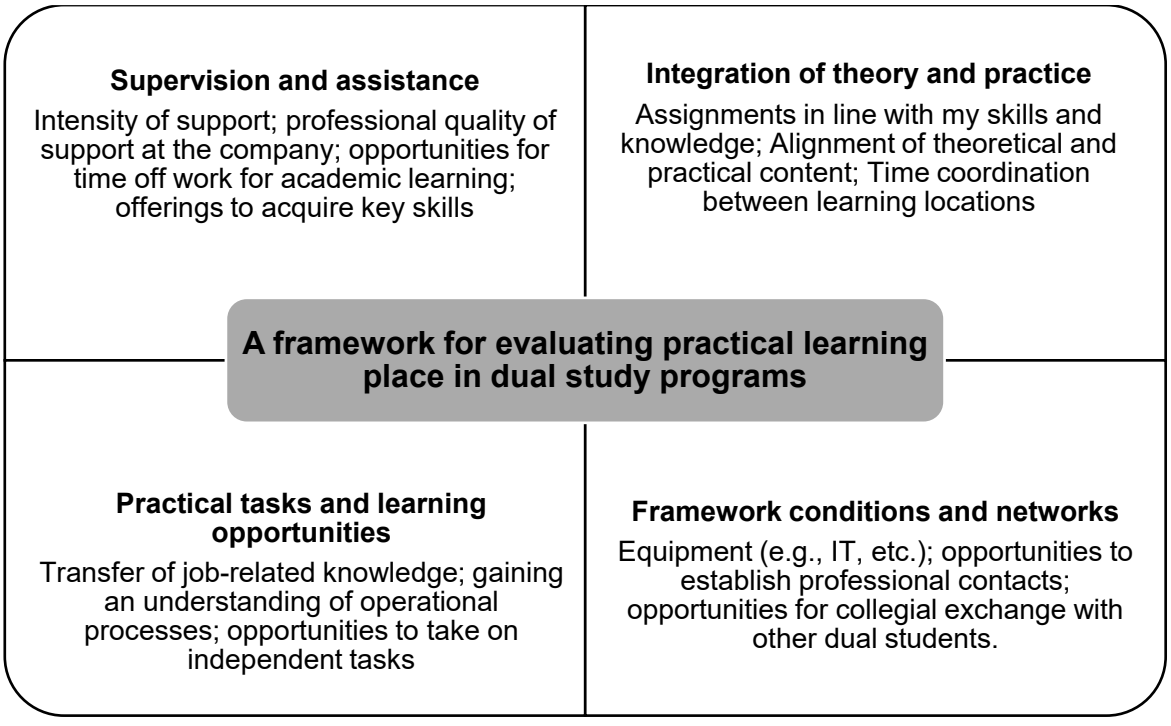


Figure 1. A framework model for evaluating the practical learning location (based on Krone et al., 2019)

The dual students were asked to rate these 13 aspects of the practical training phases using German school grades (scale 1-6; in the German school grading system, 1 is the best grade and 6 is the worst grade). This rating by students is subjective and context-dependent, but it provides

authentic information about the perceived quality of the practical training because it reflects the perspective of the dual students in a simple and understandable way.

In a second step, Pearson correlation analyses were used to analyze possible correlations between the thirteen practical training quality aspects and satisfaction with the practical training phases. The relevant question was: "Overall, how satisfied are you with the practical training phases in your study program?" Students rated this item on a scale from 1 ("dissatisfied") to 4 ("satisfied"). In addition to these correlations between practical training quality and satisfaction with the practical training phases, we also analysed if there are correlations between the perceived quality of practical training and satisfaction with the whole dual study programme (third step). We used a hierarchical cluster analysis for this purpose. However, the cluster analysis was not used exploratorily. Instead, we wanted to use this analysis to form two groups: satisfied and dissatisfied students. For this reason, the number of clusters was set a priori at two. The decision to preset two clusters is based on pragmatic considerations. To make differences as visible as possible, it makes sense to separate only two dichotomous groups. This allows a comparison of mean values between two groups, whereas three or more groups might not show these differences clearly. Furthermore, earlier analyses in which a cluster analysis was used exploratively had already indicated that there are two clusters: satisfied and unsatisfied (Rahn et al. 2022). With these two clusters, we then examined correlations between the assessment of practical quality and satisfaction with the dual study programme, for example the intention to change the course of study and/or the practical training location, or the tendency to drop out.

For the first three steps, we used data from the 2024 student survey. In a final step, we then used the new data from the 2025 student survey to validate the results of the cluster analyses with new data. In this cluster analysis more items were included to measure practice quality (see section 4.3).

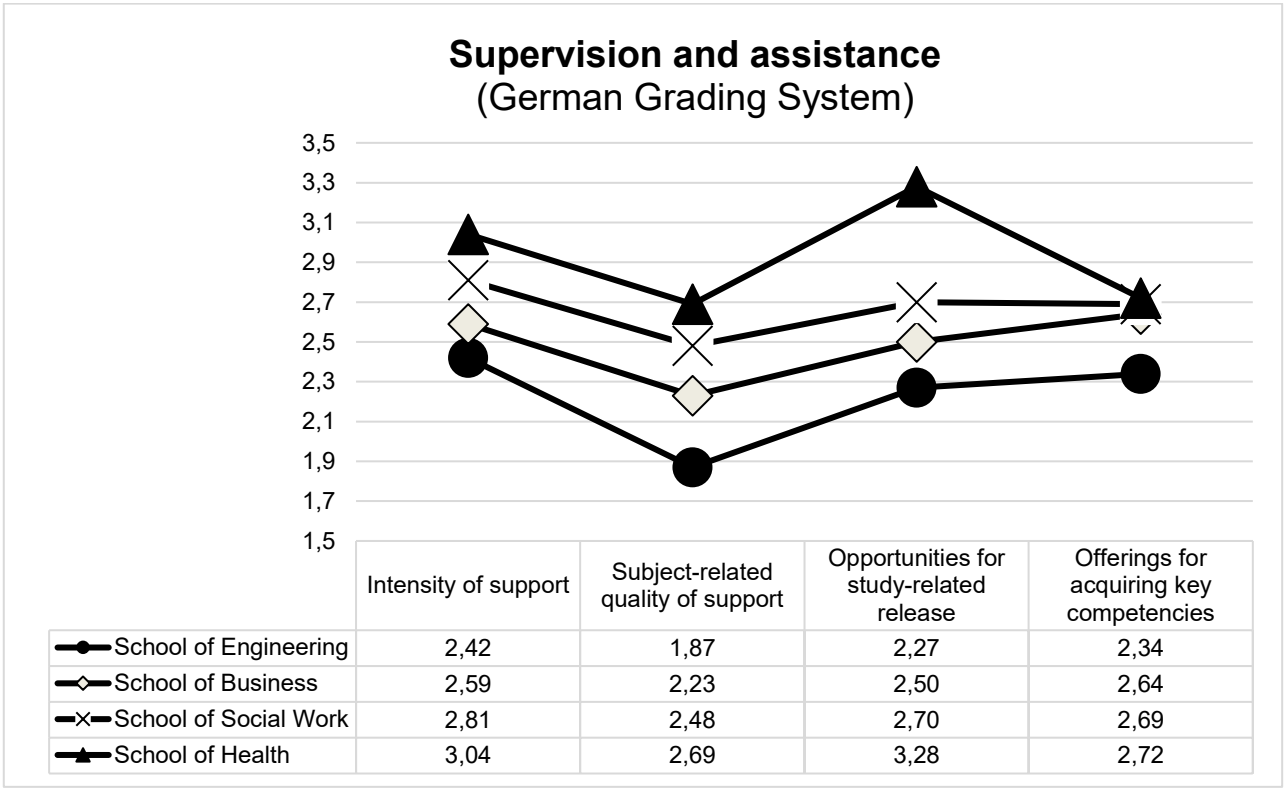
4 Results

First, descriptive findings on students' assessments of practical training quality are presented (univariate analyses). To assess practical training quality, we used German school grades and asked the students to evaluate quality using four different dimensions (supervision and support, linking theory and practice, practical tasks and learning opportunities, and framework conditions and networks). This assessment was also differentiated according to field of study. Furthermore, correlations between the assessment of practical training quality and satisfaction with the practical training phases were analysed (bivariate analyses). In a third step, a cluster analysis was used to form two groups based on the four dimensions mentioned above for assessing the quality of practical training in school grades as grouping variables: students who tended to rate practical training quality positively and students who tended to criticise practical training quality (multivariate analyses). These two groups were then compared in terms of their satisfaction with the dual study programme itself. To substantiate the robustness of the findings, a similar group comparison was also carried out using data from the 2025 student survey. Although other items relating to practical quality were used here, this group comparison also shows similar findings.

4.1 Univariate analyses: Measuring students' evaluation of practical training quality

4.1.1 Supervision and assistance

The first category includes aspects that describe the quality of supervision and personal support provided to dual students. An intensive and professionally sound level of support is essential in order to provide students with guidance, promote their individual strengths, and assist them in overcoming challenges. Organisational support, such as release time for study-related learning, also plays a key role in enabling students to connect their studies successfully with practical experience. Opportunities to acquire key competencies expand their professional knowledge through skills such as teamwork, communication, and time management. The associated criteria are therefore: intensity of support, subject-related quality of support, opportunities for study-related release, and offerings to acquire key competencies.



	Intensity of support	Subject-related quality of support	Opportunities for study-related release	Offerings for acquiring key competencies
School of Engineering	2,42	1,87	2,27	2,34
School of Business	2,59	2,23	2,50	2,64
School of Social Work	2,81	2,48	2,70	2,69
School of Health	3,04	2,69	3,28	2,72

Figure 2. Perceived supervision and assistance during the practical phases

In terms of support intensity, the field of engineering achieved the best rating with an average score of 2.42, followed by economics (2.59) and social work (2.81). The lowest rating was given to the subject area of health (3.04). The subject-related quality of support is rated most positively by all fields of study. Here, the field of engineering is clearly ahead of the other fields with an average score of 1.87. Economics (2.23), social work (2.48), and health (2.69), on the other hand, receive slightly lower ratings.

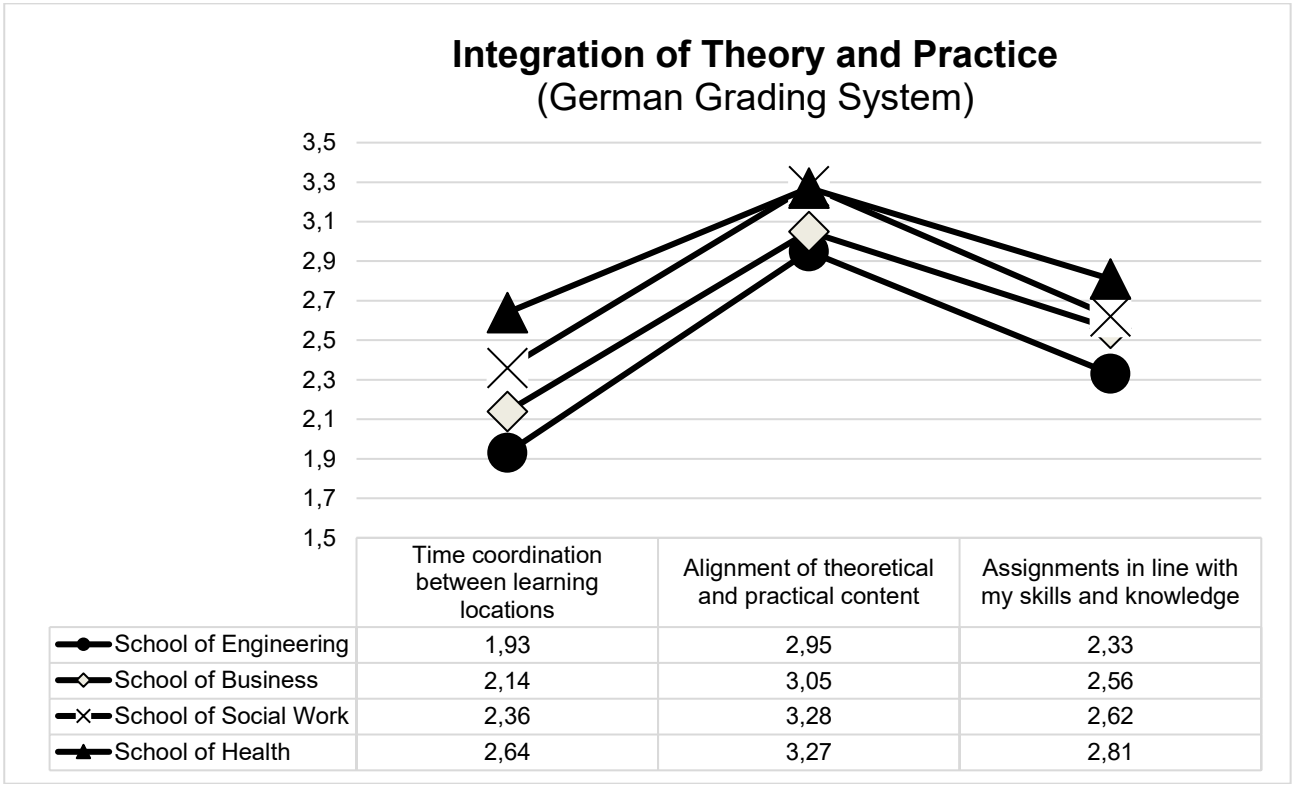
There are significant differences in the opportunities for time off for study-related learning. The field of engineering (2.27) also leads in this aspect, followed by the fields of economics (2.50) and social work (2.70). The field of health falls significantly behind with a score of 3.28. In contrast, there are fewer differences between the fields of study when it comes to offerings for acquiring key competencies. The ratings here range from 2.34 (engineering) to 2.72 (health).

In summary, students in technical degree programmes rate their practical phases most highly across all characteristics surveyed. This indicates comparatively clearly structured supervision processes in this field of study. In contrast, the weaker ratings in the health sector are striking, particularly with reference to the intensity of supervision and opportunities for time off for study-related learning. Possible explanations for this could be a higher workload for those responsible for training and less systematic training and supervision structures in healthcare institutions. Another factor might be that dual study programmes are still relatively new in this segment and therefore lack the necessary experience and systematic structures.

4.1.2 Integration of theory and practice

The integration of theory and practice is at the heart of dual study programmes. This category describes how well the learning environments at the university and the company are coordinated. Close coordination between the two areas in terms of content and timing enables students to be qualified not only academically, but also in terms of practical and application-oriented skills. It is also important that the tasks in the company correspond to the skills and academic knowledge of the students in order to achieve learning and application effects. The associated criteria are:

assignments in line with my skills and knowledge; alignment of theoretical and practical content; time coordination between learning locations.



	Time coordination between learning locations	Alignment of theoretical and practical content	Assignments in line with my skills and knowledge
School of Engineering	1,93	2,95	2,33
School of Business	2,14	3,05	2,56
School of Social Work	2,36	3,28	2,62
School of Health	2,64	3,27	2,81

Figure 3. Perceived integration of theory and practice during the practical phases

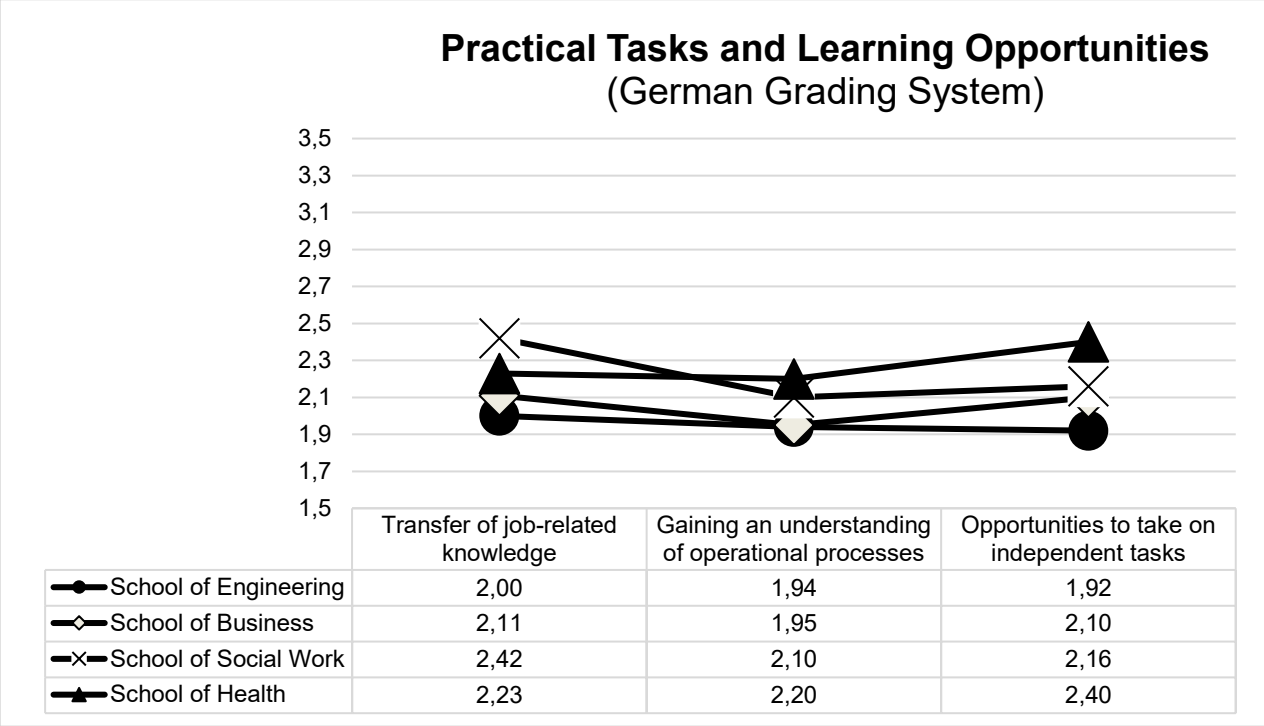
In terms of coordination between learning places (e.g., with regard to exam dates), the subject area of engineering achieved the best ratings with an average score of 1.93. The subject areas of economics (2.14) and social work (2.36) received average ratings, while the subject area of health received the lowest rating with 2.64. The highest numerical grades overall were given for the alignment of theoretical and practical content, indicating the lowest level of satisfaction within this category. The ratings range from 2.95 in the field of engineering to 3.28 in the field of social work. With regard to the aspect of assignments in line with students' own skills and knowledge, the ratings are also mainly in the "satisfactory" range. Here, too, the field of engineering received the best rating at 2.33, followed by economics (2.56), social work (2.62), and health (2.81).

In this category, it is evident that, from the students' perspective, the time coordination between the university and its practice partners works well overall, especially in the engineering field. This indicates established structures and clear communication processes. However, students are less satisfied with the integration of theory and practice in terms of content. Here, the ratings for all fields of study range from just below to slightly above 3.0, which indicates moderate satisfaction. The use of students' own skills and academic knowledge is also mainly rated in the middle range. Students in the fields of health and social services feel less that they are being employed in accordance with their level of qualification than students in technical degree programmes. Possible reasons for this may be structural, such as standardised activities or fewer creative opportunities in certain fields of practice.

4.1.3 Practical training tasks and learning opportunities

The category "Practical Tasks and Learning Opportunities" describes the learning opportunities that arise through work activities in the company. Insight into operational processes gives students a comprehensive understanding of how the company or institution works and how different processes are connected. At the same time, the teaching of professional knowledge is the

basis for their professional development. Opportunities to take on independent tasks are particularly valuable, as they promote independence and a sense of responsibility and prepare students for future professional challenges. The associated criteria are: transfer of job-related knowledge; gaining an understanding of operational processes; opportunities to take on independent tasks.



	Transfer of job-related knowledge	Gaining an understanding of operational processes	Opportunities to take on independent tasks
School of Engineering	2,00	1,94	1,92
School of Business	2,11	1,95	2,10
School of Social Work	2,42	2,10	2,16
School of Health	2,23	2,20	2,40

Figure 4. Perceived practical tasks and learning opportunities during the practical phases

In terms of transfer of job-related knowledge, the area of engineering leads with an average grade of 2.00, followed by the areas of economics (2.11), health (2.23), and social work (2.42). Opportunities to take on independent tasks were rated very positively overall. Students from the fields of technology and economics rate this just below 2.0, while those from the fields of social work and health rate it slightly above. The ratings are also consistently good when it comes to opportunities to take on independent tasks. The field of engineering achieved the best rating here with 1.92, followed by economics (2.1) and social work (2.16). The field of health (2.4) followed some way behind. Engineering received the strongest ratings across all three aspects.

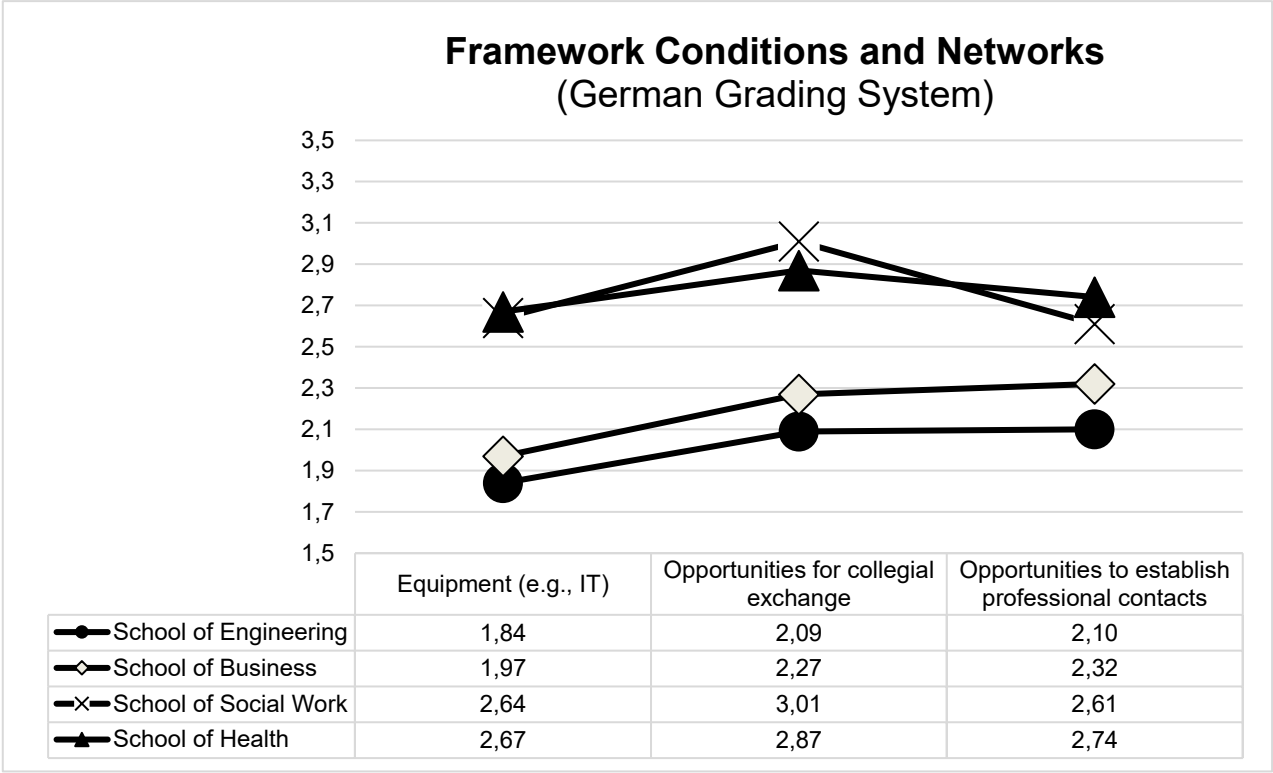
The results in this category are more positive overall than in the areas considered previously. This suggests that the practical training phases work well, particularly in terms of professional qualification and practical integration. It is particularly notable that all ratings are between 1.92 and 2.42, i.e., in the upper satisfaction range. This observation suggests that students are successfully integrated into company structures and processes.

The slightly better scores in the field of engineering may be related to the fact that there are traditionally well-defined training structures (often in the form of training workshops) and students are often involved in production tasks and projects at an early stage.

4.1.4 Framework conditions and networks

A supportive working environment and the establishment of professional networks are key conditions that significantly influence the success of practical training phases. The availability of appropriate equipment - such as required technology or well-equipped workstations - not only facilitates daily work but also creates favourable conditions for efficient and practical learning. In addition, opportunities for networking offer valuable social and professional benefits. Such networks can be an important basis for further career development by providing professional support, informal

exchange, and potential career prospects. The results in this category are based on the following criteria: equipment (e.g., IT, technology, workstations), opportunities to establish professional contacts, and opportunities for collegial exchange with other dual students.



	Equipment (e.g., IT)	Opportunities for collegial exchange	Opportunities to establish professional contacts
School of Engineering	1,84	2,09	2,10
School of Business	1,97	2,27	2,32
School of Social Work	2,64	3,01	2,61
School of Health	2,67	2,87	2,74

Figure 5. Perceived framework conditions and networks in the practical phases

In terms of equipment (e.g., IT, technology, workplace, work equipment), the area of engineering achieved the best ratings with an average grade of 1.84. The area of economics also received a very positive rating of 1.97. In comparison, the areas of social work (2.64) and health (2.67) performed significantly worse, indicating a less well-equipped working environment in these areas. Overall, the opportunities for collegial exchange with other dual students were rated somewhat more reservedly. While the fields of study engineering (2.09) and economics (2.27) are in the good to satisfactory range, social work (3.01) and health (2.87) show significantly lower satisfaction ratings. A similar picture emerges when it comes to opportunities to establish professional contacts. Here, too, the field of engineering achieved the best rating with 2.10, followed by economics (2.32), social work (2.61), and health (2.74). These results suggest that the practical phases in the fields of engineering and economics offer better conditions for networking and exchange than social work and health.

The evaluations in this category show that the material and structural conditions vary significantly between the four different areas of study. In the technical and economic fields of study in particular, students clearly benefit from well-equipped workstations and a professional infrastructure. This is reflected in the very positive ratings. In the fields of social work and health, however, the ratings are significantly lower. This suggests that, in these fields of practice, less technical equipment or fewer standardised workstations may often be available.

There are also clear differences between the fields of study in terms of collegial exchange and establishing contact with relevant actors. Students in the fields of engineering and economics report comparatively good opportunities to build networks and exchange professional knowledge. In contrast, students in the fields of social work and health care seem to be less involved in student networks. Possible reasons for this are likely to be structural factors, such as greater isolation in smaller institutions or shiftwork, which can make continuous exchange difficult.

4.2 Bivariate Analyses: Correlations between the rating of practical training quality and satisfaction with the practical training phases

In a second step, Pearson correlation analyses were used to analyse correlations between the 13 aspects of practical training quality and satisfaction with the practical training phases. The results show consistently significant negative correlations, which can be attributed to the fact that lower values on the scales (i.e., better school grades) express higher satisfaction. Thus, stronger negative correlations indicate a closer positive relationship between the respective quality characteristic and satisfaction.

The strongest correlations are visible in the characteristics of support intensity and professional quality of support ($r = -0.49$, $p < 0.01$ in each case). The correlations with the teaching of professional knowledge, with learning about operational processes, with deployment in line with students' own abilities and knowledge, and with the correspondence between theory and practice are also clearly pronounced ($r = -0.43$, $p < 0.01$ in each case).

Somewhat weaker but still significant correlations were found for opportunities for collegial exchange ($r = -0.41$, $p < 0.01$), opportunities to establish career-relevant contacts ($r = -0.36$, $p < 0.01$), and opportunities to learn key skills ($r = -0.35$, $p < 0.01$). The correlations with opportunities to take on independent tasks ($r = -0.32$, $p < 0.01$), time off for study-related learning ($r = -0.27$, $p < 0.01$), equipment ($r = -0.26$, $p < 0.01$), and coordination of schedules between learning places ($r = -0.25$, $p < 0.01$) are comparatively lower, but remain statistically significant.

Overall, this analysis shows that quality features in the area of support and professional integration have the strongest correlations with satisfaction levels. General conditions - such as equipment or time coordination - also showed significant correlations, but these were less pronounced.

4.3 Multivariate Analyses: Correlations between ratings of practical training quality and satisfaction with the dual study programme

Previous findings from DHBW-wide student surveys illustrate that there appears to be a correlation between students' perceptions of practical training quality and overall satisfaction with dual study programmes (see section 2.3). This finding should therefore be validated again using data from the 2024 student survey, using the four-dimensional construct of practical training quality with 13 individual items described in section 3. As described above, this evaluation of practical training quality was rated using a German school grading scale (1-6).

To enable group comparisons, a hierarchical cluster analysis (Ward method) was used, including all 13 aspects. In this case, however, a two-cluster solution was preset. The intention was to separate satisfied from dissatisfied individuals. The two-cluster solution was then used to identify any differences in mean values. The overall index of practical training quality, satisfaction with practical training supervision, the propensity to change the subject of study, the propensity to change the practical training location, and the propensity to drop out were used. Table 1 shows the differences in mean values.

Table 1. Mean differences between dissatisfied and satisfied students (2024 student survey, n=1,991)

	Practical training quality (school grades 1-6) (index)**	Satisfaction with practical training support (scale 1=low to 7=high) (index)**	Tendency to change subject of study (scale 1=low to 4=high)**	Tendency to change practical training location (scale 1=low to 4=high)**	Tendency to drop out of study programme (scale 1=low to 4=high)*
Dissatisfied (n=711)	3,3	4,7	2,0	2,3	2,3
Satisfied (n=1,280)	1,9	6,1	1,8	1,4	2,1
Total (1,991)	2,3	5,6	1,8	1,7	2,1

* significant at p<0.05
** significant at p<0.001

Overall, these findings confirm that students who are dissatisfied with the quality of practical training in their company are also more likely to change their practical training placement and slightly more likely to change their field of study or drop out. There is also a relatively major difference in terms of satisfaction with practical training supervision, which in turn highlights the key importance that supervisors and mentors can have during practical training phases.

Since data from the 2025 student survey is now also available, a further group comparison is possible, analogous to the approach used for the 2024 student survey (two-cluster solution). However, since the role and importance of practical supervision were a particular focus of the 2025 survey, additional items beyond the 13 aspects described in section 3 were used to operationalise practical training quality, with a specific focus on supervision. The total number of these additional items in the 2025 survey is 18. The quality of practical supervision was measured using 11 items (scale 1=does not apply at all to 7=applies completely):

- My practical supervisors ...
  - ... give me recognition after I have completed a difficult task.
  - ... take time for me when I have questions.
  - ... assign me challenging tasks.
  - ... give me access to all the information I need (e.g., computer systems, databases).
  - ... help me find solutions to problems.
  - ... encourage me to tackle new tasks.
  - ... let me know how well I am doing my job.
  - ... promote my professional development through constructive criticism.
- My practical supervisors have a high level of professional competence.
- My practical supervisors are able to explain complex content to me in an understandable way.
- My practical supervisors are informed about the system and rules of the dual study programme.

In addition, seven further items relating to the quality of practical training phases were used (scale 1=does not apply at all to 7=applies completely):

- During the practical training phases, I can apply the theoretical content learned during the study phases at university.
- The area of application and task planning in the practical operation are coordinated with the learning content of the related study phases.
- The practical supervisors regularly explain how practical professional activities are linked to academic theories/methods.

- Measures are taken to...
  ... help me understand the organisational structure of my practical training company.
  ... make it clear to me how my area of work fits into the overall operation.
  ... inform me about the areas of work and tasks of my colleagues.
  ... illustrate to me how my work contributes to the overall performance of my work area.

However, the group comparison based on a cluster analysis (two clusters: dissatisfied versus satisfied) shows similar findings for these items. In this case, too, dissatisfied students also have a higher intention to change their internship placement (Table 2, right columns). This survey also asked further questions regarding satisfaction with the study programme, the practical training company, and the DHBW (Table 2, left columns). These questions also show clear and significant differences: dissatisfied students would be less likely to choose the same degree programme and the same practical training company again. The mean values also differ when it comes to the question of whether students would choose the DHBW again. However, the differences here are not statistically significant.

There are also differences between satisfied and dissatisfied students when it comes to their intentions to change (change of study subject, cooperating company) and drop out tendency.

Table 2. Mean differences between dissatisfied and satisfied students (2025 student survey, n=2,092)

		If I could start over again...					
	Practical training quality (scale 1-7) (index)**	... I would choose the same study programme again (scale 1=strongly disagree to 7=strongly agree)**	... I would choose the same practical training company (scale 1 = strongly disagree to 7 = strongly agree)**	...I would choose DHBW again (scale 1=strongly disagree to 7=strongly agree)	Tendency to change the subject of study (scale 1=low to 4=high)*	Tendency to change the practical training location (scale 1=low to 4=high)**	Tendency to drop out of study programme (scale 1=low to 4=high)*
Dissatisfied (n=414)	3,3	4,7	3,5	4,9	1,9	2,5	2,1
Satisfied (n=1678)	5,0	5,3	5,8	6,0	1,7	1,5	2,0
Total (n=2092)	4,6	5,2	5,3	5,8	1,7	1,7	2,0

* significant at p<0.05
** significant at p<0.001

Figure 6 shows that this correlation is ultimately reflected in the fact that dissatisfied students tend not to want to continue working at their current company after completing their studies. Only about 15% of dissatisfied students planned to stay at their company in the long term after completing their study programme. In the satisfied group, this proportion is much higher. Almost half of them would work there after completing their studies.

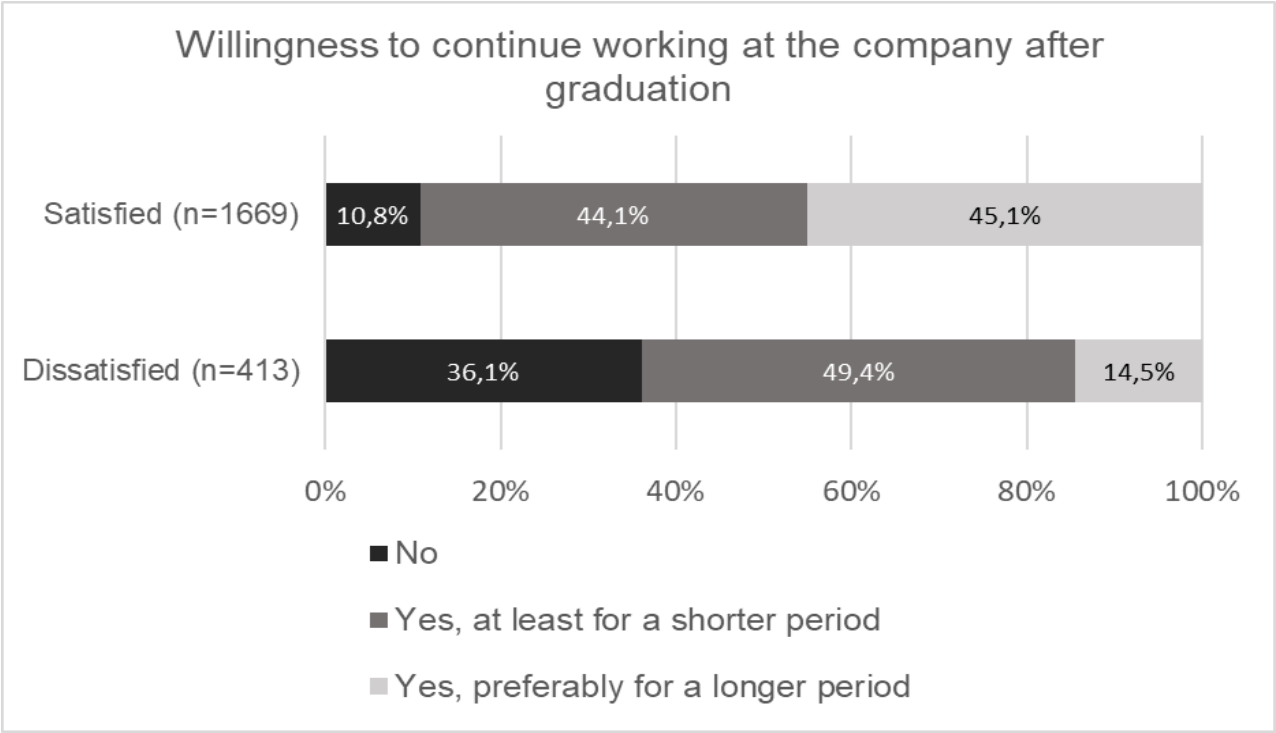


Figure 6. Correlation between rating of practical training quality and willingness to work at the cooperating company after graduation.

In this respect, the perceived quality of practical training also plays an important role in staff retention; after all, companies and institutions invest considerable financial resources in dual students on the basis of contractually agreed salary payments.

5 Discussion and conclusions

The results of the student survey from 2024 show a mostly positive picture of the practical training phases, but there are clear differences between the different areas of study. The field of engineering received the highest ratings overall. This indicates well-established practical training structures and a tailored design of the practical training phases in this area. The correlation analyses show that all practical training quality characteristics are significantly related to satisfaction with the practical training experience. These correlations are particularly strong in terms of the intensity of supervision and the professional quality of supervision, which are therefore key factors influencing a positive perception of the practical training phases.

The chosen methodological approach of measuring the quality of practical training phases using German school grades is associated with a number of limitations that must be critically considered. On the one hand, these are subjective assessments that may be influenced by individual expectations, personal experiences, and situational conditions. Students do not exclusively evaluate objective quality characteristics, but always their personal experience of the practical training. Nevertheless, school grades are a low-threshold and easily understandable instrument that enables a differentiated assessment of perceived quality from the students' perspective. The supplementary correlation analysis with overall satisfaction also shows that the assessments are systematic and plausible: characteristics that are particularly important in conceptual terms - such as the quality of supervision or the connection between theory and practice - show the strongest correlations with satisfaction. Overall, despite certain limitations, the chosen survey method provides a reliable basis for assessing perceived practical training quality. At the same time, it provides clear approaches for the further development of the dual practical training phases, especially in areas closely related to student satisfaction.

Furthermore, a comparison between students who generally rated the practical training phases more negatively and those who rated them more positively showed differences in satisfaction with the dual study programme itself, reflected in differences in mean values for intentions to switch study programmes and propensity to drop out. However, these differences are particularly pronounced when it comes to satisfaction with the practical training placement. Unsurprisingly, satisfied students are also more likely to say that they can imagine working at the respective training institution on a long-term basis after completing their studies. One limitation of our evaluation, however, is that the quality of practical training examined does not allow for any well-founded conclusions to be drawn about the actual skills acquired by the students. This correlation could be examined in more detail in future studies.

The results provide a basis for several recommendations: In addition to strengthening the quality of support and improving the integration of theory and practice, it is particularly important to actively create learning and development spaces in companies and to promote exchange and networking structures. The companies are called upon to implement these standards on site, ensure quality supervision, and create targeted learning opportunities that meet academic requirements. The desire for more intensive exchange between the two learning locations was expressed several times in another survey of companies conducted in 2025. In addition, the need for student participation is pointed out in the academic literature (Arens-Fischer & Dinkelborg 2020; DGB-Jugend 2023; DGB Bundesvorstand 2019; Krone 2023).

Such efforts are also worthwhile because they increase the likelihood that students want to continue working at their cooperating companies and institutions after completing their studies. Given the trend towards a shortage of skilled workers, such investments are also investments in the future of companies and institutions. Accordingly, universities and cooperating institutions should agree on a corresponding quality initiative.

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European Scientific Journal for Dual Higher Education

Vol. 2, No. 1, (2026)
ISSN (online): 3052-7015

STRATEGIC INNOVATION BY DESIGN IN DUAL HIGHER EDUCATION: EMBEDDING ETHICAL, SUSTAINABLE LEADERSHIP THROUGH WORK-INTEGRATED POSTGRADUATE LEARNING

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Keywords:
Design thinking
Responsible research and innovation (RRI)
Dual higher education
PBEE framework
Work-based learning

Article history:
Received: 2 December 2025
Revised: 25 March 2026
Accepted: 21 May 2026

Abstract

Dual higher education increasingly requires pedagogical approaches that integrate academic learning with the complexity of contemporary organisational challenges. This paper examines how the Perception-Blueprint-Envision-Execution (PBEE) framework, a structured design-led pedagogical scaffold, is embedded in work-integrated postgraduate learning to support ethical, sustainable, and systems-oriented innovation. Drawing on the Sustainable Design for Innovation (SDI) module, the paper analyses how PBEE structures learners' engagement with transformational workplace projects addressing sustainability, responsible leadership, and organisational complexity. Adopting a conceptual and practice-based orientation, the analysis illustrates how PBEE supports structured sensemaking around organisational context, problem framing, responsible solution generation, and reflective engagement with implementation. The paper positions PBEE as a pedagogical model aligned with the development of Future Skills, including reflexivity, problem framing, ethical awareness, stakeholder engagement, and adaptability. In doing so, it contributes a coherent design-led framework for advancing societally relevant and responsible innovation within dual higher education.

1 Introduction

1.1 Context: Dual higher education in a changing world

Rapid technological, environmental, and societal shifts are reshaping the capabilities required of contemporary organisations and their workforces. The World Economic Forum's Future of Jobs Report (2025) highlights the accelerating demand for organisations to navigate AI-enabled transformation while strengthening responsible leadership, ethical governance, and resilience (Chiu, 2024). Employers increasingly prioritise analytical and creative thinking, collaboration, adaptability, and social influence in a labour market shaped by automation, sustainability transitions, and demographic change (Alt et al., 2023; Doherty & Stephens, 2023; World Economic Forum, 2025).

Dual and work-integrated higher education models are particularly well positioned to respond to these demands because they formally integrate academic learning with sustained professional practice (Smith & Worsfold, 2014; Ferns et al., 2025). In this paper, dual higher education refers to educational models that integrate academic study with workplace-based application and support

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reflective integration, professional agency, and competence development through authentic organisational challenges (Ferns et al., 2025; Sági & Fülöp, 2024). Empirical studies indicate that such models can enhance soft skills, professional competence, and learner agency at master's level (Prada et al., 2022; Urkia-Basterra et al., 2025).

Within this context, work-integrated postgraduate learning can serve as a critical mechanism for bridging theory and practice in ways that support societal relevance and professional readiness. The Sustainable Design for Innovation (SDI) module examined in this paper represents such an approach by enabling learners to undertake transformational projects within their own organisations. To support sustainability-oriented and ethically informed innovation practice, the module uses the Perception-Blueprint-Envision-Execution (PBEE) framework as a design-led pedagogical scaffold.

1.2 Purpose of the study

Despite growing interest in dual higher education and work-integrated learning, limited practice-based insight exists into how structured pedagogical scaffolds can operationalise sustainability, ethical responsibility, and systems thinking within postgraduate professional contexts. Although design thinking and responsible innovation scholarship emphasise the importance of reflexivity, stakeholder engagement, and societal alignment (Brown, 2009; Freeman, 1984; von Schomberg, 2013), there remains a gap in understanding how such principles can be embedded coherently in work-integrated postgraduate curricula.

The purpose of this study is to examine how the PBEE framework, a design-thinking-inspired pedagogical scaffold, supports competence development, learner agency, and societal relevance within a work-integrated postgraduate module. Drawing on conceptual scholarship in design thinking, responsible innovation, and stakeholder theory, and informed by qualitative, practice-based evidence from the SDI module, the paper explores how PBEE structures learner inquiry, reflection, and action throughout transformational workplace projects.

1.3 Research Questions

The study is guided by the following conceptual questions, which are explored through a qualitative, practice-based analysis of a work-integrated postgraduate module rather than through hypothesis testing:

- How can PBEE support competence development in dual higher education?
- How does the SDI module empower student agency through real-world, work-integrated projects?
- What Future Skills emerge when postgraduate learners apply PBEE within their professional context?
- How can responsible innovation and stakeholder theory provide a conceptual foundation for understanding the societal relevance of work-integrated postgraduate learning?

1.4 Contribution to the literature

This paper makes four key contributions to existing literature on dual higher education, design-led pedagogy, and responsible innovation. It also contributes to current discussions on how work-integrated learning curricula can be structured to support transformational capability development among postgraduate learners (Ferns et al., 2025). Although critical scholarship highlights the value of design thinking as a practice-oriented, context-sensitive approach to innovation (Kimbell, 2011), it has also been applied in diverse professional contexts to support problem framing and stakeholder engagement (Kenny et al., 2021). However, limited pedagogical guidance remains on how such design-led frameworks can be systematically embedded in work-integrated postgraduate curricula to support ethical, sustainable, and societally relevant innovation capability development.

First, it proposes PBEE as a pedagogical scaffold that supports transformative, work-integrated postgraduate learning. PBEE is presented as a structured practical learning process that

guides perception, problem framing, ideation, and execution within real-world professional settings (Brown, 2009; Ferns et al., 2025; Kenny et al., 2021; Urkia-Basterra et al., 2025), while stakeholder identification and salience provide a useful lens for understanding organisational dynamics (Mitchell, Agle & Wood, 1997).

Second, the study integrates concepts from design thinking, responsible innovation (RRI), and stakeholder theory to illustrate how pedagogical design can encourage learners to adopt ethical, inclusive, contextual, and systems-based perspectives on organisational and societal challenges (Freeman, 1984; Blok & Lemmens, 2015; von Schomberg, 2013). Responsible innovation scholarship emphasises anticipation, reflexivity and responsiveness in addressing societal challenges (Macnaghten et al., 2014; Owen et al., 2021).

Third, the paper contributes practice-based evidence from authentic work-integrated projects undertaken by postgraduate learners. These vignettes illustrate how students use PBEE to navigate sustainability issues, digital transformation, social impact challenges, and product/service innovation. Table 1 positions PBEE in relation to established design and innovation frameworks, clarifying its distinctive responsible and work-integrated orientation.

Table 1. Conceptual positioning of PBEE in relation to established design and innovation frameworks

Framework	*Core organising logic*	*Treatment of sustainability and ethics*	*Role of stakeholders*	*Orientation to responsibility and societal impact*	*Primary application context*
IDEO Design Thinking (Desirability–Feasibility–Viability)	Human-centred problem solving balancing user needs, feasibility, and viability	Treated as contextual considerations rather than structuring principles	Primarily framed as users or customers	Indirect; dependent on design intent rather than embedded criteria	Product, service, and organisational innovation
Double Diamond (Design Council)	Divergent–convergent cycles of problem definition and solution development	Sustainability and Ethics may be incorporated but not structurally embedded	Engaged mainly during discovery and testing	Focus on problem–solution fit rather than explicit societal responsibility	Design process management and innovation practice
Responsible Research and Innovation (RRI)	Normative framework emphasising anticipation, reflexivity, inclusion, and responsiveness	Central normative commitments	Core principle across the innovation process	Explicit focus on societal desirability, ethics, and public value	Science, technology, and innovation governance
PBEE (Perception–Blueprint–Envision–Execution)	Pedagogical scaffold guiding contextual analysis, systems-framing, responsible ideation, and reflective implementation	Embedded across all stages as boundary conditions for innovation decisions	Engaged throughout the process as part of sensemaking, framing, and evaluation	Societal impact is foregrounded through reflexive inquiry and responsible innovation principles	Work-integrated postgraduate learning and professional education

Fourth, the paper aligns PBEE with the development of Future Skills and transformative capabilities identified as central to dual higher education and contemporary policy frameworks (European Commission, 2018; European Commission, 2023; OECD, 2024; Prada et al., 2022; Urkia-Basterra et al., 2025). These include problem-solving, reflexivity, ethical reasoning, adaptability,

systems thinking, stakeholder engagement, collaboration, and innovation capability. By enabling students to choose transformative projects within their own workplaces, the module embeds agency, responsibility, and professional relevance at the heart of the learning process.

1.5 Structure of the paper

The paper is structured as follows. Section 2 outlines the conceptual and methodological orientation of the study, including the pedagogical context of the SDI module and the PBEE scaffold that supports work-integrated learning. Section 3 presents thematic vignettes from learners' transformational projects and discusses the development of competencies and Future Skills. Section 4 examines PBEE's contribution to dual higher education and its alignment with societally relevant pedagogy. Section 5 concludes by reflecting on implications for practice, limitations and directions for future research.

2 Methodology

2.1 Research design and conceptual orientation

This paper adopts a conceptual, qualitative, and practice-based methodological orientation, drawing on pedagogical scholarship, experiential learning theory, and design-based learning approaches in postgraduate management education. The methodological purpose is to examine pedagogical design and curriculum architecture in a work-integrated learning context, rather than to conduct an empirical study of learners or evaluate learning outcomes.

Experiential learning theory provides a foundational lens for the analysis. As articulated by Kolb (1984), experiential learning conceptualises learning as a cyclical process of concrete experience, reflective observation, conceptual interpretation, and active experimentation, making it particularly well suited to work-integrated and real-world innovation projects. Similarly, action learning approaches - where learners engage with authentic organisational challenges through iterative cycles of inquiry, analysis, and reflection - have long been recognised for their role in developing leadership capability, problem-solving capacity, and reflective judgement in professional education (Marquardt, 2014; Revans, 1982; Volz-Peacock et al., 2016). These approaches align closely with the work-integrated structure of the Sustainable Design for Innovation (SDI) module examined in this paper. This practice-based methodological stance also responds to critiques suggesting that responsible innovation frameworks can become overly procedural, with limited attention to power, politics, and institutional uptake in real organisational contexts (van Oudheusden, 2014).

The study is situated within constructivist epistemological traditions that view knowledge as co-constructed, situated, and context-dependent (Guba & Lincoln, 1989), while also drawing on reflexive methodological perspectives that recognise the researcher's interpretive role in meaning-making (Alvesson & Sköldberg, 2009). Within this framing, pedagogical design is understood as an embedded professional practice shaped by institutional context, disciplinary norms, and practitioner judgement. Accordingly, the unit of analysis in this paper is the design and enactment of the SDI module, including its curriculum structure, learning architecture, and integration of the PBEE framework, rather than individual students or participant characteristics.

The analysis focuses on how the Perception-Blueprint-Envision-Execution (PBEE) framework is embedded within a work-integrated postgraduate module and how it functions as a pedagogical scaffold within authentic professional projects. References to student engagement are used illustratively to demonstrate how the framework is enacted within the learning design, rather than as empirical evidence derived from systematic data collection, or outcome measurement. The pedagogical stance underpinning this analysis is informed by professional experience at the intersection of academia and industry. Working across these domains has highlighted the importance of perception, contextual awareness, and practical problem-solving in effective innovation practice. This experience shapes the rationale for the SDI module design, which emphasises empathy, systems thinking, and real-world application. These principles underpin the

choice of experiential action learning and the integration of PBEE as the guiding framework for learning design. This aligns with reflexive practitioner research traditions that emphasise critical engagement with professional experience while remaining attentive to its interpretive limits (Cunliffe, 2003, 2016, 2020).

This conceptual and practice-based orientation informs the following sections, which outline the context, structure, and pedagogical architecture of the SDI module. All illustrative student material referenced in this paper derives from routine teaching and assessment processes and was not generated for research purposes. As such, the study does not involve human subjects research, and all examples are presented as anonymised educational artefacts used to support a conceptual discussion of pedagogical design.

2.2 PBEE framework as pedagogical and analytical lens

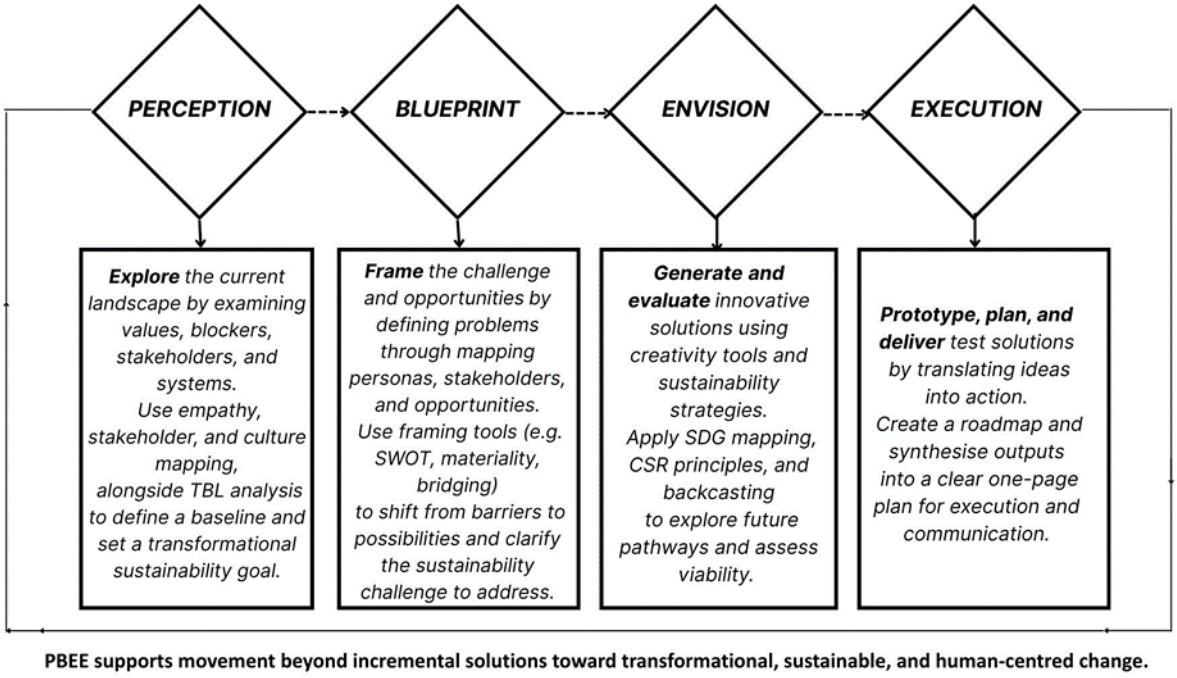

Figure 1. The PBEE framework as a reflexive scaffold for responsible and sustainable innovation

2.3 Context of the SDI module

The Sustainable Design for Innovation (SDI) module forms part of a part-time postgraduate MBA programme and has been delivered across multiple cohorts since its introduction in 2023. It has evolved through ongoing pedagogical refinement informed by practitioner insight. Learners are working professionals drawn from diverse sectors, primarily multinational organisations, alongside government agencies and, to a lesser extent, start-ups and owner-managed SME's. In the Irish context, SMEs are defined as enterprises with fewer than 250 employees and categorised as micro (<10 employees), small (10-49), or medium (50-249), with additional financial thresholds applied in funding contexts (CSO, 2024).

Given the professional backgrounds of participants, the module adopts an experiential action learning approach that emphasises doing, reflecting, and revising practice. Learning is structured through the design thinking-inspired PBEE framework (Perception, Blueprint, Envision, Execution) and supported by continuous reflective activities. Figure 1 illustrates the PBEE learning model as introduced in the SDI module and outlines the four interconnected stages that guide learner engagement throughout the innovation process.

To operationalise PBEE, students work in a structured Miro workspace that mirrors the four stages of the framework. This digital environment guides learners through stakeholder mapping, sustainability analysis, ideation, prototyping, and reflective synthesis. The workspace supports accountability and iterative learning by making decision-making processes visible across the module. It also provides a visual trace of the innovation journey used within assessment activities. Figure 2 presents the Miro workspace used to scaffold learner engagement with the PBEE process.

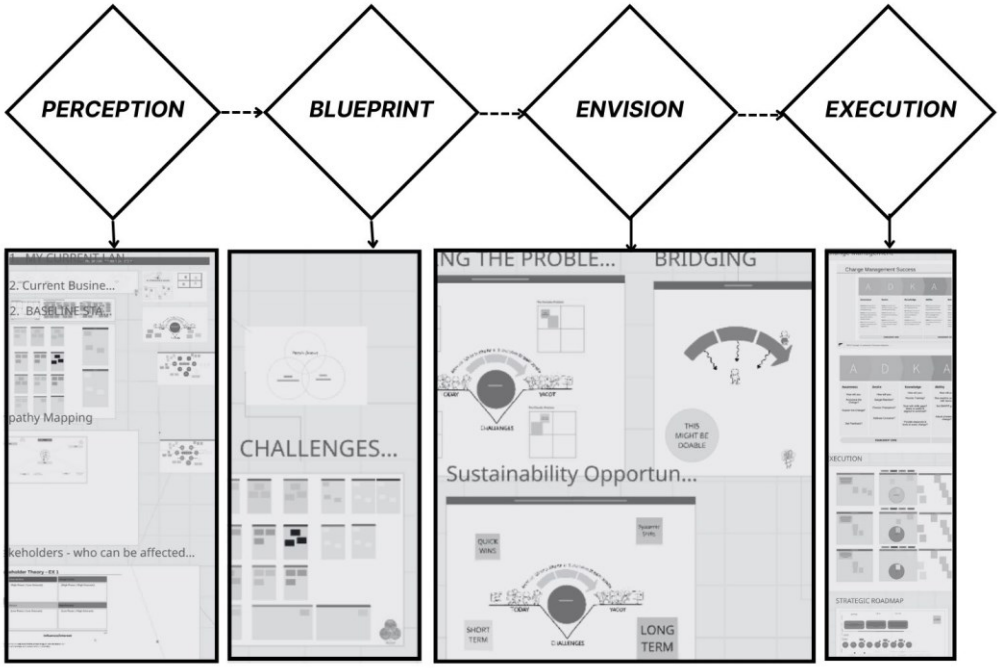

Figure 2. Miro workspace used to scaffold learner engagement with the PBEE process.

The SDI module places particular emphasis on sustainability, ethical leadership, and systems thinking. Experiential learning tasks encourage learners to analyse interconnected challenges, evaluate environmental and social impacts, and develop responsible innovation proposals within their own organisational contexts. Students are required to select a transformational workplace project that demonstrably addresses sustainability and inclusion, thereby ensuring that innovation is purpose-driven and contextually relevant. A formative project pitch in Week 3 provides an opportunity to present proposed projects, receive feedback, and confirm feasibility within the module timeframe.

2.4 Learning activities and assessment structure

Learning within the SDI module is organised around three interconnected assessments designed to scaffold the application of the PBEE framework throughout of the module.

2.4.1 Assignment 1: Sustainable design for innovation proposal (individual)

Students prepare an initial project brief outlining their chosen transformational workplace project. This proposal requires analysis of environmental and social impacts, identification of relevant stakeholders, mapping of sustainability considerations, including ESG and SDG alignment, and articulation of SMART objectives. The output establishes the foundation for subsequent learning activities and assessments.

2.4.2 Assignment 2: Collaborative product redesign (group hackathon)

Midway through the module, students participate in a collaborative redesign challenge focused on improving the sustainability performance of an existing product. Working with predefined products that present sustainability challenges, groups apply rapid design methods informed by lifecycle analysis, materiality considerations, relevant legislation, and sustainability principles. Outputs include a short presentation, a design rationale, and supporting documentation.

2.4.3 Assignment 3: Transformational project presentation (individual)

In the final assessment, students present the outcomes of their workplace innovation projects. They reflect on implementation processes, compare planned and actual progress, consider feasibility and potential impact, and discuss organisational barriers and enablers. The presentation synthesises learning across the module and demonstrates applied integration of PBEE, sustainability principles, and responsible innovation within a real-world professional setting.

Together, these learning activities form a coherent, practice-based learning architecture designed to support competence development, reflective capability, and responsible innovation leadership in a work-integrated postgraduate context.

2.5 Data and practice-based evidence sources

Since its introduction, the SDI module has been delivered across multiple cohorts, with approximately 65 postgraduate learners engaging with the PBEE framework through assessed transformational projects and reflective coursework. The analysis presented in this paper draws on practice-based educational artefacts generated through routine teaching and assessment processes, including project proposals, collaborative hackathon outputs, final project presentations, and structured reflective submissions. In addition, longitudinal practitioner observation of project development and classroom engagement informed interpretive insights into how the PBEE framework operates in practice in a work-integrated postgraduate learning context.

These materials are not treated as data for statistical measurement, systematic qualitative coding, or causal inference. Rather, they are considered at an aggregate and illustrative level to support interpretive sensemaking around recurring pedagogical patterns, thematic project trajectories, and modes of learner engagement enabled by the PBEE scaffold. This interpretive orientation aligns with qualitative traditions that emphasise meaning-making and pattern recognition without formal analytic procedures (Braun & Clarke, 2006). All examples referenced are anonymised and used solely to support a conceptual discussion of pedagogical design and learning architecture, rather than to report evaluative findings or generalisable evidence of learner outcomes.

3 Results and discussion

3.1 Overview of PBEE in practice

Within the Sustainable Design for Innovation (SDI) module, the Perception-Blueprint-Envision-Execution (PBEE) framework is used as a pedagogical scaffold through which learners structure and navigate transformational workplace projects. Rather than functioning as a prescriptive method, PBEE provides a staged learning architecture that supports contextual exploration, structured problem framing, responsible ideation, and reflective consideration of implementation in work-integrated postgraduate learning settings.

Across module deliveries, PBEE has been enacted in a wide range of organisational and sectoral contexts. Although the specific focus of workplace challenges varies, the framework offers a consistent structure through which learners engage with sustainability-oriented inquiry, leadership considerations, and systems-level constraints. The emphasis in this analysis is therefore on how PBEE organises thinking, reflection, and professional sensemaking rather than on evaluating individual learner outcomes.

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To illustrate the pedagogical architecture underpinning the SDI module, Figure 3 presents a conceptual cycle showing how PBEE is embedded in a wider work-integrated learning process. The model situates learner-identified workplace challenges at the centre of the learning experience, supported by academic input, structured learning activities, assessment, and iterative feedback loops. In this way, PBEE operates as a connective mechanism between professional practice and academic learning, enabling sustained engagement with responsible and sustainability-oriented innovation within real-world organisational contexts.

3.2 Perception: Understanding complex contexts

Within the SDI module, the perception stage foregrounds values-led leadership and contextual awareness at the outset of learners' transformational projects. At this stage, PBEE emphasises the articulation of personal and organisational values alongside examination of internal beliefs, structural constraints, and contextual pressures shaping workplace practice. This pedagogical focus reflects scholarship highlighting the importance of ethical voice and the organisational and societal costs associated with moral disengagement or "looking the other way" (Gentile, 2012).

The Perception stage also incorporates principles associated with psychological safety and collaborative cultures as enabling conditions for innovation (Bunderson & Boumgarden, 2010; Carmeli, 2007; Carmeli & Gittell, 2009; Edmondson, 1999, 2004, 2014; Tucker et al., 2007). These concepts are embedded within learning activities to support open engagement with complexity and uncertainty in professional contexts.

In practice, this stage structures sensemaking activities, such as mapping organisational processes, exploring user journeys, identifying key stakeholders, and analysing contextual constraints. These activities support learners in surfacing ethical considerations, sustainability tensions, and systemic or digital challenges relevant to their organisations. The focus is on developing contextual insight and reflexive awareness, providing a foundation for subsequent problem framing and design work.

Beyond its immediate pedagogical role, the Perception stage aligns with broader competence development priorities within Dual Higher Education. As shown in Table 2, this stage supports the development of reflexivity, ethical awareness, and systems awareness, contributing to learners' capacity to exercise professional judgement within work-integrated learning settings.

Table 2. PBEE stages mapped to competence in dual higher education

PBEE Stage	*Work-Integrated Learning Activities*	*Competence Areas Emphasised (Future Skills)*	*Dual Higher Education Alignment*
Perception	Context analysis, stakeholder mapping, values clarification, ethical questioning	Reflexivity, ethical awareness, systems awareness	Understanding workplace context; developing professional judgement
Blueprint	Problem framing, systems mapping, materiality analysis, barrier–opportunity mapping	Analytical thinking, strategic awareness, problem framing	Translating academic tools into authentic challenges
Envision	Ideation, scenario-building, responsible design, sustainability evaluation	Creativity, responsible innovation, adaptive thinking	Generating organisationally relevant solutions
Execution	Prototyping, feasibility testing, workplace engagement, reflective learning	Collaboration, leadership, communication, practical judgement	Applying learning within real work settings

Source: Author's conceptual framework (PBEE)

3.3 Blueprint: Structured problem framing

The Blueprint stage supports the transition from broad contextual exploration to structured problem framing. At this stage, learners apply systems thinking tools to identify interdependencies, examine underlying causal structures, and move beyond surface-level symptoms. This approach aligns with systems thinking perspectives that emphasise relationships and feedback structures rather than isolated issues (Meadows, 2008).

Pedagogical activities in the Blueprint stage focus on mapping competing priorities, stakeholder expectations, and inclusion-related considerations that shape organisational challenges. This structured framing process reflects core design thinking principles emphasising reframing of initial problem definitions to surface deeper and more strategically relevant challenges (Dorst, 2011). Attention to stakeholder salience further supports clearer articulation of organisational problem contexts (Mitchell et al., 1997).

Through this stage, PBEE functions as a scaffold that organises analytical inquiry and supports deliberate engagement with complexity, establishing a foundation for subsequent ideation and envisioning activities.

3.4 Envision: Creative and responsible ideation

The Envision stage focuses on the generation of creative, responsible, and sustainability-oriented solution concepts. Learning activities draw on principles of eco-design and circular economy thinking to support ideation that considers environmental, ethical, and organisational implications (Bocken et al., 2014; Geissdoerfer et al., 2017). Scenario-building and impact assessment encourage reflection on potential consequences of proposed solutions, consistent with responsible innovation frameworks (von Schomberg, 2013).

This stage reflects design thinking practices that balance creativity with responsibility and feasibility (Brown, 2009). Through structured ideation, PBEE supports engagement with future-oriented considerations such as adaptability, ethical reasoning, and imaginative problem-solving, aligning with emerging Future Skills priorities in sustainability-oriented innovation contexts (Caeiro-Rodríguez et al., 2021; Kenny et al., 2021).

3.5 Execution: From concept to practice

The Execution stage reflects core principles of work-integrated and action learning, in which conceptual ideas are explored within authentic professional settings (Ferns et al., 2025; Revans, 1982). At this stage, PBEE structures engagement with prototyping, feasibility exploration, stakeholder feedback, and reflective consideration of implementation pathways.

Workplace constraints, such as organisational culture, regulation, resources, and timeframes shape how execution unfolds, highlighting the situated nature of innovation practice. Reflective activities embedded within this stage align with experiential learning models that emphasise action and reflection as central to professional learning (Kolb, 1984; Volz-Peacock et al., 2016). As such, the Execution stage foregrounds practical judgement, leadership awareness, and collaborative engagement within real-world contexts.

3.5.1 Thematic project vignettes

Analysis of assessed transformational projects and associated reflective submissions across multiple SDI cohorts reveals recurring thematic patterns that illustrate how PBEE operates in practice in work-integrated postgraduate learning. These vignettes are drawn from routine assessment artefacts and practitioner observation and are presented to illustrate the range of organisational contexts, challenge types, and innovation trajectories supported by the framework.

A prominent theme across projects relates to organisational culture as both an enabler and a constraint of innovation, reflecting established links between workplace culture, leadership norms, and innovation capacity (Schein, 2010). PBEE provided a structured means for engaging with ethical

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tensions, sustainability trade-offs, and systems-level constraints embedded in everyday organisational practice.

Several projects focused on sustainability and community-oriented innovation, including lifecycle assessment, waste reduction initiatives, and sustainability-aligned financial products. These projects align with approaches to sustainable value creation and business model innovation that integrate economic, environmental, and societal considerations (Osterwalder & Pigneur, 2010). Other vignettes addressed digital and AI-enabled transformation, including process redesign, data transparency, and user journey optimisation, reflecting the growing role of digital technologies in sustainability-oriented innovation (Chiu, 2024; OECD, 2024).

Across thematic areas, reflective submissions consistently engaged with questions of ethical responsibility, long-term societal impact, and the challenges of implementing change in constrained organisational environments. Rather than evidencing learning outcomes, these reflections provide insight into how PBEE structures professional sensemaking and supports engagement with complexity and leadership responsibility. Similar patterns are reported in wider studies of work-integrated and dual master's programmes across Europe (Ferns et al., 2025; Smith & Worsfold, 2014; Urkia-Basterra et al., 2025).

Table 3 provides an overview of the thematic distribution of transformational projects, illustrating the diversity of sectors, innovation challenges, and areas of focus through which PBEE has been enacted in practice.

Table 3. Overview of transformational projects undertaken by learners

Theme	*Sector Examples*	*Type of Challenge*	*Illustrative Project Focus*
Sustainability & Community Innovation	Semi-state, finance, manufacturing	LCA, waste reduction, green lending	Sustainability related KPIs
Market/System Level Innovation	Biomedical, logistics	Prototyping, service innovation	Biomedical device prototype, e-cargo concept
Digital & AI Transformation	Public services, marine environment	User journey redesign, data transparency	User journey redesign, data transparency
Health & Social Impact	Disability services, wellbeing programmes	Accessibility, inclusion	Improved documentation, inclusive programme design
Product/Process Innovation in SMEs	Hair & beauty, medtech	Waste reduction, workflow redesign	Operational process improvements

Source: Author's synthesis of illustrative student project themes drawn from assessed coursework.

3.5.2 Sustainability and community innovation

A number of assessed transformational projects focused on sustainability and community-oriented innovation in organisational contexts. One project situated in a semi-state enterprise used the PBEE framework to explore place-based sustainability opportunities by mapping stakeholder interests, long-term environmental targets, and potential community co-benefits. In the financial sector, a project examined the development of a sustainability-aligned lending concept, considering feasibility, organisational risk appetite, and green finance principles. In a manufacturing context, another project explored waste reduction in production processes, applying lifecycle thinking to identify opportunities for material efficiency. These projects illustrate how PBEE structures engagement with complex sustainability challenges that span environmental, organisational, and societal systems, consistent with systems thinking perspectives (Meadows, 2008; Fry, 2009). The vignettes align with responsible innovation scholarship emphasising anticipation, inclusion, and societal alignment within innovation processes (von Schomberg, 2013; Macnaghten et al., 2014).

3.5.3 Innovation with market- or system-level potential

A subset of assessed transformational projects focused on innovations with potential organisational, market, or system-level relevance. These projects drew on rapid prototyping and creativity tools consistent with design-driven innovation practices (IDEO, 2015). One project situated within the biomedical sector explored the redesign of a medical waste container component, resulting in a functioning prototype and consideration of potential pathways for industry collaboration. Such exploratory prototyping aligns with design-led innovation scholarship that emphasises iteration, experimentation, and cross-sector engagement (Brown, 2009; Kenny et al., 2021). Other projects addressed service and system-level challenges. In the transport and logistics domain, one project developed a sustainability-oriented last-mile delivery concept using e-cargo solutions, applying PBEE to analyse feasibility, stakeholder needs, and environmental implications. In a hospital context, another project examined the transition from paper-based medical device instructions to a digital alternative, engaging with regulatory requirements and operational constraints.

Although these projects remained at early or exploratory stages of development, they illustrate how PBEE structures opportunity identification, problem framing, and the articulation of responsible and sustainable innovation pathways within real-world professional settings. The emphasis on feasibility, stakeholder consideration, and ethical awareness reflects core principles of design thinking and responsible innovation (Kimbell, 2011; von Schomberg, 2013).

3.5.4 Digital and AI transformation in SMEs

A subset of assessed transformational projects focused on digital transformation and service redesign in public and semi-public organisational contexts. One project situated in a national social protection service examined the user journey for jobseekers, identifying barriers to navigating digital pathways and proposing a more integrated and inclusive support model. Such challenges are well documented within digital transformation research, particularly in public service and SME contexts where legacy systems and accessibility issues persist (European Commission, 2025; OECD, 2024).

Another project applied the PBEE framework to explore how open data tools could enhance transparency and stakeholder engagement in marine environmental protection within a government department. Across these examples, the projects illustrate how PBEE structures engagement with stakeholder mapping, empathy-based inquiry, and feasibility analysis to identify opportunities for digital or service redesign. The focus on accessibility, transparency, and ethical service delivery reflects broader principles of digital inclusion and stakeholder-centred design (Chiu, 2024; Interreg Europe, 2024).

3.5.5 Health, wellbeing and social impact projects

A number of assessed transformational projects addressed social impact challenges in community organisations, health settings, and support services. One project situated within a disability employability service examined organisational sustainability documentation and client-facing materials, proposing a more accessible and ethically aligned digital resource. Another project focused on the enhancement of a wellbeing programme, using the PBEE framework to balance user needs, organisational constraints, and long-term inclusivity considerations.

These projects illustrate how PBEE structures engagement with empathy-based inquiry, reflexive sensemaking, and ethical judgement in socially responsive innovation contexts. This emphasis aligns with scholarship on reflexive practice and ethical leadership (Cunliffe, 2003, 2020) and with research highlighting the role of psychological safety and learning-oriented leadership in enabling inclusive and responsible organisational change (Edmondson, 2014, 2018). Collectively, the vignettes demonstrate how PBEE functions as a pedagogical scaffold for translating ethical and responsible leadership principles into practical interventions within social and community-facing services.

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3.5.6 Process innovation and leadership in workplaces

A number of assessed transformational projects undertaken in SME contexts focused on product development, process innovation, and operational efficiency. One project situated in the hair and beauty sector explored the development of a new product concept aimed at reducing industry waste and improving health and safety practices. Another project, located within a medical context, applied the PBEE framework to the early-stage development of a multi-purpose support device, examining patient needs, innovation feasibility, and potential pathways for prototyping and stakeholder engagement.

Other projects addressed internal organisational processes, identifying opportunities for workflow redesign or more sustainable resource use. Collectively, these vignettes illustrate how PBEE structures strategic problem framing and iterative exploration within smaller organisational settings where resources and capacity may be constrained. This emphasis on action-oriented inquiry and reflective problem-solving aligns with action learning scholarship highlighting the role of real workplace challenges in supporting leadership judgement and practical decision-making (Revans, 1982; Volz-Peacock et al., 2016).

3.5.7 Learner reflections and competence alignment

Across thematic areas, reflective submissions provide insight into how learners engaged with complex organisational challenges, ethical considerations, and systems-level thinking through the PBEE framework. These reflections are used illustratively to examine how structured innovation processes support professional sensemaking in work-integrated postgraduate learning, rather than as evidence of measured competence development.

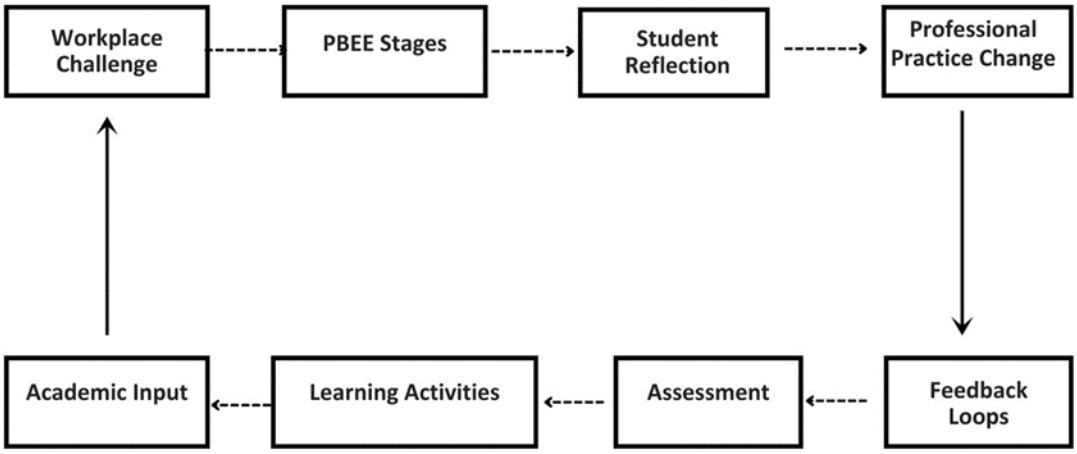

Figure 3. Integration of the PBEE framework within a work-integrated dual higher education learning cycle[*]

Recurring reflective themes include renewed attention to systems thinking, ethical awareness, stakeholder engagement, and sustainability-oriented problem framing. Several reflections describe

* This conceptual cycle illustrates how learner-selected workplace challenges are explored through the PBEE stages, supported by academic input, structured learning activities, assessment, and iterative feedback loops. The model highlights how PBEE is embedded within a work-integrated learning architecture that enables learners to reflect on their professional context and engage with responsible, sustainability-oriented innovation within workplace settings.

shifts towards more holistic consideration of organisational challenges, reconnecting strategic intent with everyday professional decision-making. Others emphasise reflexive questioning of assumptions, empathic consideration of multiple perspectives, and heightened awareness of ethical risks in supply chains and sustainability transitions. These themes resonate with scholarship on reflexive practice and systems thinking in professional education (Cunliffe, 2003; Meadows, 2008).

Rather than indicating learning outcomes, the reflections illustrate alignment between PBEE-enabled reflective activity and competence areas commonly associated with work-integrated and dual higher education, including ethical reasoning, adaptability, strategic awareness, and future-oriented transversal competences (Ferns et al., 2025; Sá & Serpa, 2022). Across submissions, PBEE is described as a useful scaffold for integrating sustainability considerations into professional practice and supporting reflective engagement with leadership challenges in complex organisational environments. Table 4 presents selected student micro-reflections mapped to dual higher education competence areas, illustrating alignment with PBEE-supported reflective practice.

Table 4. Examples of student micro-reflections mapped to dual higher education competences[*]

Reflection Insight	*Competence Category*
"I regained a holistic perspective I'd lost in my managerial role"	Systems thinking / strategic awareness
"PBEE forced me to revisit assumptions and deepen my empathy"	Ethical reasoning / empathy
"I see supply chains differently now - including modern slavery risks"	Ethical awareness / critical reflection
"The structure gave me confidence to plan sustainable projects"	Agency / problem-solving

3.6 PBEE's contribution to dual higher education

The integration of PBEE into the SDI module aligns closely with the aims of dual higher education by structuring connections between academic concepts and real-world professional practice. Through learner-selected workplace projects, PBEE provides a coherent process for exploring complex organisational issues, framing sustainability-oriented opportunities, generating responsible solutions, and reflecting on implementation.

PBEE's emphasis on systems analysis, stakeholder awareness, and iterative reflection foregrounds competence areas widely associated with dual higher education, including ethical reasoning, adaptability, collaborative engagement, and professional judgement (Alt et al., 2023; Caeiro-Rodríguez et al., 2021; Meadows, 2008; Mitchell et al., 1997). This positioning aligns PBEE with contemporary DHE competence frameworks rather than presenting it as a mechanism for measuring learning outcomes. Taken together, the project vignettes illustrate how the SDI module operationalises the aims of dual higher education through a structured, design-led learning architecture. Within this context, PBEE functions as a pedagogical scaffold that supports integration of academic learning with meaningful professional engagement, consistent with responsible innovation principles emphasising anticipation, inclusion, and societal alignment (Macnaghten et al., 2014; OECD, 2024; von Schomberg, 2013).

3.7 PBEE as a model for societally relevant higher education

Building on the preceding analysis, this section offers a conceptual synthesis of PBEE's alignment with societally relevant higher education agendas rather than introducing additional empirical findings. The PBEE scaffold aligns closely with the aims of societally relevant higher education by structuring learner engagement with real-world challenges that have environmental, social, or ethical significance. Contemporary higher education is increasingly called upon to

* Note. Reflections are presented as anonymised illustrative examples drawn from assessed reflective coursework and are not intended as evaluative evidence of learning outcomes.

foreground sustainability, responsibility, and societal contribution in professional learning (OECD, 2024; European Commission, 2018). By requiring learners to examine context, stakeholders, systems, and potential long-term consequences, PBEE encourages forms of inquiry that extend beyond organisational boundaries and foreground societal considerations.

This positioning reflects the principles of responsible innovation, which emphasise anticipation, reflection, inclusion, and responsiveness in addressing complex societal challenges (von Schomberg, 2013; Macnaghten et al., 2014). Within the SDI module, PBEE provides a structured lens through which sustainability, accessibility, public service improvement, supply chain responsibility, and digital inclusion can be examined as interconnected design challenges situated in professional practice.

Table 5 positions PBEE in relation to core domains of societally relevant higher education, illustrating how its staged structure aligns with established scholarly and policy frameworks. Across these domains, PBEE foregrounds values clarification, systems awareness, reflexive iteration, and workplace alignment as integral components of learning design rather than as discrete outcomes to be measured.

Table 5. Positioning PBEE against societally relevant higher education goals

Societal Relevance Domain	*PBEE Contribution*	*Supporting Literature*
Sustainability & Ethics	Context analysis, RRI-guided ideation, long-term impact reflection	von Schomberg (2013); Macnaghten et al. (2014)
Agency & Responsibility	Values clarification, stakeholder engagement	Cunliffe (2003); Alt et al. (2023)
Systems Thinking	Blueprint systems mapping, materiality analysis	Meadows (2008)
Reflexivity & adaptability	Iterative reflection across all stages	Edmondson (2014)
Work-integrated professional competence	Practical implementation, workplace alignment	Ferns et al. (2025); Smith & Worsfold (2014)

Source: Author's conceptual synthesis, informed by the cited literature.

In this sense, PBEE functions as a pedagogical anchor that supports engagement with agency, responsibility, and ethical sensitivity in complex professional and societal contexts. This aligns with scholarship on reflexive and values-led leadership, which emphasises the importance of critically examining assumptions, power relations, and ethical implications in practice (Cunliffe, 2003). The framework's structured and iterative design supports holistic problem framing and consideration of wider impacts, consistent with contemporary accounts of Future Skills associated with sustainability transitions and digital transformation (Caeiro-Rodríguez et al., 2021; Alt et al., 2023).

By embedding PBEE in work-integrated learning, the SDI module illustrates how design-led, reflective, and responsibility-oriented pedagogies can align higher education with societal needs while maintaining professional relevance. In this context, PBEE contributes a transferable pedagogical model for higher education programmes seeking to integrate sustainability, ethics, and systems thinking within authentic professional learning environments (Ferns et al., 2025; Smith & Worsfold, 2014).

4 Conclusions

4.1 Summary of contributions

This paper has examined how the PBEE scaffold, when embedded in a work-integrated postgraduate module, aligns with the aims of dual higher education by structuring connections between academic concepts and real-world organisational challenges. Adopting a conceptual and practice-based orientation, the analysis has focused on pedagogical design, learning architecture,

and the role of PBEE as a design-led scaffold supporting professional sensemaking in authentic workplace contexts.

The paper illustrates how PBEE provides a structured pathway for engaging with complexity through staged attention to context, systems, stakeholder perspectives, and reflective iteration. Across the SDI module, the framework functions as a transparent learning architecture that supports inquiry into sustainability-oriented challenges, responsible innovation, and implementation considerations without reducing learning to predefined outcomes. In this respect, PBEE aligns with competence areas commonly associated with Future Skills and societally relevant higher education, including systems awareness, ethical sensitivity, reflexivity, and collaborative engagement.

This contribution is situated within wider European and international policy agendas that emphasise sustainability, digital capability, and transversal competences as central to future-oriented professional education. Frameworks such as the EU Green Deal, Pact for Skills, Digital Decade 2030, EntreComp, GreenComp, DigComp, and the OECD Skills for 2030 agenda consistently highlight the need for learning approaches that integrate ethical reasoning, adaptability, systems thinking, and applied problem-solving. By foregrounding these dimensions within a work-integrated learning structure, PBEE offers a pedagogical model that is conceptually aligned with these priorities.

For educators and programme designers, the analysis suggests that structured innovation frameworks such as PBEE can complement existing dual higher education models by offering a coherent, iterative scaffold that links conceptual learning with professional practice. More broadly, the paper positions PBEE as a transferable pedagogical approach for higher education programmes seeking to integrate sustainability, ethics, and systems thinking within authentic, practice-based learning environments.

4.2 Limitations and recommendations for future research

This study is limited to a single postgraduate module and adopts a conceptual, practice-based orientation that draws on practitioner-generated educational artefacts rather than empirical measurement. As such, the analysis does not seek to produce generalisable findings. Future research could explore the application of PBEE or comparable structured innovation frameworks across additional dual higher education contexts, examine learner engagement and competence alignment through mixed-methods approaches, or conduct comparative studies across institutions, sectors, and national settings.

Notwithstanding these limitations, the analysis contributes to growing scholarship on work-integrated and societally relevant higher education by illustrating how design-led pedagogical scaffolds can structure connections between academic learning and professional practice. In doing so, it highlights the potential of structured, reflective, and responsibility-oriented learning architectures to support the broader educational mission of dual higher education in contexts characterised by complexity, sustainability challenges, and rapid change.

Ethical declaration

This article presents a conceptual and practice-based analysis of curriculum and pedagogical design in a postgraduate module. No human-subjects research was conducted. Illustrative examples drawn from routine teaching and assessment activities, including anonymised and non-identifiable student reflections, are used solely to support pedagogical discussion. These materials were generated as part of standard educational practice and are not treated as research data. Accordingly, formal institutional ethics approval was not required.

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European Scientific Journal for Dual Higher Education

Vol. 2, No. 1, (2026)
ISSN (online): 3052-7015

DUAL HIGHER EDUCATION IN DENMARK: LEGAL FRAMEWORK, APPLICATION AND EDUCATIONAL PATHS

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Keywords:
Denmark
Dual education
VET
Learning pathways

Article history:
Received: 7 January 2026
Revised: 1 April 2026
Accepted: 20 May 2026

Abstract
Denmark's education system is frequently characterised by its flexibility and permeability, enabling progression between vocational and academic pathways. Within this context, elements of dual learning are embedded at multiple levels, including professional higher education and selected university programmes. This article examines the legal, structural, and institutional foundations of Dual Higher Education (DHE) in Denmark. Drawing on a qualitative document analysis of national legislation, policy documents, and institutional use cases, the study analyses how dual principles are framed in law and implemented in practice. The article reviews the literature on dual education models and explores the legislative framework that shapes vocational and higher education. It also considers dual education pathways and institutional practices through selected case examples, highlighting how regulatory structures interact with institutional strategies to combine workplace-based learning and academic instruction across different educational tracks. The analysis reflects on the transferability of the Danish model and identifies key factors that influence the implementation of dual learning in higher education.

1 Introduction

Denmark is a Nordic country in Northern Europe, consisting of the Jutland Peninsula and an archipelago of more than 400 islands. It is recognised for its stable welfare system, high standard of living, and long-standing democratic governance. Copenhagen, the capital city, functions as the country's political, cultural, and economic centre, hosting key government institutions, universities, and major industries.

Denmark has a constitutional monarchy combined with a parliamentary democracy. The monarch serves as the ceremonial head of state, while executive power rests with the Prime Minister and the government, which are accountable to Parliament. The Parliament is a unicameral legislative body composed of elected representatives, and it is responsible for creating laws, approving the national budget, and overseeing government policies.

The Danish education system is predominantly publicly funded and designed to ensure equal access for all citizens. It is organised into primary, secondary, and higher education levels, with each stage structured to provide both academic knowledge and practical skills. Vocational education and training (VET) constitutes an important component of this system, offering students career-focused pathways that combine classroom learning with practical workplace experience. Vocational training programmes are well established and closely connected to the labour market, often through dual

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training models in which students devide their time between school-based instruction and on-the-job training. This integration supports skill development that meets the evolving needs of Danish industries.

In this article, the term “dual higher education” is used as an analytical concept rather than as a formally established category within the Danish higher education system. Denmark does not operate a system of dual higher education characterised by parallel enrolment in higher education institutions and formal employment contracts governed by a unified national framework. Instead, Danish higher education includes a range of practice-oriented and professionally oriented programmes that incorporate elements of work-based learning.

Denmark is a member of the European Union (EU). Nonetheless, its national legal frameworks and governance of education remain autonomous, shaping the way in which EU-level policies, including dual education and vocational training frameworks, are implemented and adapted within the country.

This work is part of the EU4Dual project, a European initiative to establish a European Dual Studies University. The project aims to analyse the legal frameworks of dual learning across several European countries, including, for example, France (Merlo et al., 2023), Belgium (Dupouy et al., 2024a), and Luxembourg (Dupouy et al., 2024b).

This article provides a comprehensive understanding of dual education in Denmark, beginning with a review of relevant studies and theoretical frameworks. It then outlines the research method used to analyse the topic, followed by an examination of the legislative framework governing education and vocational training. The discussion continues with an overview of the various dual education pathways available to students and highlights institutional use cases that illustrate how universities and colleges implement these programmes. Finally, the article explores the implications of these findings and concludes with a summary of key insights and recommendations for future practice.

2 Literature review

Since the late 1980s, the Danish government has introduced several changes to improve vocational education and training. These changes include the 1989 VET Reform, which simplified the structure of VET programmes, the 1996 reform of Commercial VET programmes, and Reform 2000, which focused on innovation and development at vocational schools (Stenström & Lasonen, 2000). In the mid-2010s, Denmark also introduced a special education programme for VET teachers. The aim was to improve teaching methods and enhance the skills of teachers at VET colleges (Duch & Andreasen, 2015).

Despite these progressive reforms, the attractiveness of VET programmes has decreased, as evidenced by declining enrolment rates and high dropout numbers among enrolled students. Proposals include re-evaluating the role of VET within the educational framework by advocating for a mandatory 12-year schooling system (Aarkrog, 2020);

While institutions like the European Centre for the Development of Vocational Training (Cedefop) provide periodic insights into Denmark's VET landscape, a comprehensive analysis of its dual education system remains incomplete. Current literature, such as (Stenström & Lasonen, 2000), often lacks a detailed connection between legislative frameworks and students’ practical learning trajectories. Other existing reports, such as those by Christian Helms Jørgensen from 2014 (Jørgensen, 2013), provide valuable historical context but fall short of capturing recent developments. There is therefore a need for updated and detailed studies that bridge these gaps and provide insights into the evolving dynamics of Danish vocational education and training systems.

In light of these gaps, this paper offers a comprehensive analysis of Denmark's dual education landscape. By examining recent legislative changes and their practical implications for student learning paths, the study provides a detailed and up-to-date assessment VET programmes in Denmark.

3 Method

The study aims to describe the available dual learning pathways in Denmark and to analyse how educational institutions integrate dual learning into their programmes. The first step is a literature review to establish what has already been achieved and where the gaps remain. This is followed by a document study (Figure 1).

The documents are drawn from two distinct sources: legislative bodies and educational institutions. These sources require differentiated analytical treatment. Legislative documents are characterised by technical and formalised language. In contrast, institutional documents are shaped by communicative and strategic purposes, often presented in a promotional manner.

To address the question of dual learning pathways, a comprehensive document analysis of legislative and regulatory materials was conducted across Denmark. This analysis clarifies the legal framework governing dual learning in each region, including statutory requirements, accreditation standards, and guidelines for institutional implementation. Based on these findings, dual learning pathways were mapped to illustrate how students can progress through the system from ages of 14 to 23, highlighting potential career trajectories and connections between vocational education, higher education, and the labour market.

To analyse how educational institutions integrate dual learning into their programmes, a qualitative document analysis was conducted to collect best practices from educational institutions, with three institutions selected as a case studies in Denmark. A structured analytical framework consisting of 34 guiding questions was developed to examine the available information systematically. Data were collected exclusively from publicly accessible online sources, including institutional websites, official reports, policy documents, published use cases, and promotional materials.

The analytical framework was organised into seven thematic categories, each addressing a key aspect of dual education: the definition of dual learning, institutional mission and vision, structure of educational programmes, collaboration with dual partners, programme implementation processes, faculty involvement, student experiences, and challenges encountered. Each category contained multiple questions, often requiring descriptive answers. For clarity and analytical simplicity, the responses presented in this paper have been reformulated into binary yes/no format, allowing a structured comparison across themes and facilitating interpretation of institutional practices.

Footnotes were added where necessary to clarify the rationale behind specific binary (yes/no) classifications, particularly in cases where institutional information required interpretative judgement or where nuances could not be fully captured by a dichotomous format.

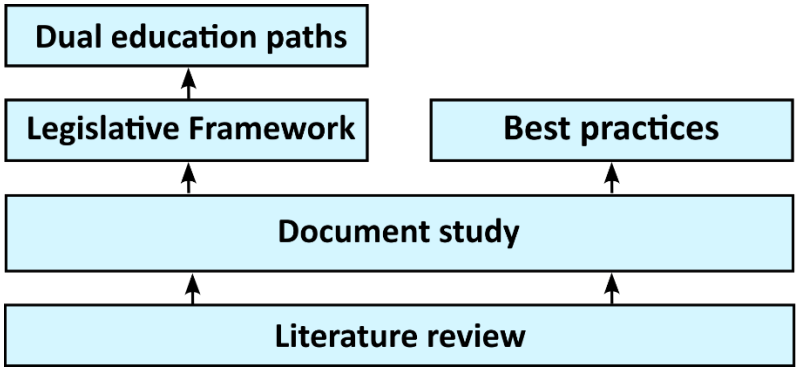

Figure 1. Research design used in this article

4 Legislative framework

Denmark's vocational education and training system has undergone significant transformation since its origins, evolving beyond the traditional apprenticeship model, which closely resembled the German dual system. The development of Denmark's modern VET framework began with the Apprenticeship Act of 1956, which established the legal foundation for a more diversified and

structured dual education model (Andersen & Helms, 2019). Over time, this model expanded to include a variety of vocational pathways designed to meet the needs of different learner groups and sectors.

Upon completion of compulsory education (typically after the 9th grade), students transition to the upper secondary level (European Qualifications Framework (EQF) levels 3-4), where they choose between general and vocational education pathways (Jørgensen, 2013). The vocational track offers three main options:

- Vocational Education and Training (Danish: Erhvervsuddannelse, abbreviated: EUD): This programme prepares students for employment in specific sectors such as agriculture, commerce, technical trades, and healthcare. EUD combines theoretical instruction in vocational schools with extensive workplace-based training, typically lasting between three and four years. Theoretical components are delivered at certified training institutions (Executive order on vocational education and training, 2021).
- Vocational Education and Training including General Upper Secondary Exam (Danish: Erhvervsuddannelse med gymnasial eksamen, abbreviated: EUX): Introduced in 2012, the EUX pathway integrates vocational education with general academic education. Approximately 50% of the programme involves work-based learning, and students graduate with both a journeyman's certificate and a general upper secondary diploma. This dual qualification enables access to higher education and supports the needs of academically motivated students. The EUX programme generally spans 4 to 5 years and is available in commercial and technical fields (Act on the vocational upper secondary education (EUX), 2022).
- Vocational Education and Training for Adults (Danish: Erhvervsuddannelse for voksne, abbreviated: EUV): Designed for learners aged 25 and above, EUV parallels the EUD structure but adapts content and duration according to the individual's prior work experience. Programme length typically ranges from three to four years (Andersen & Helms, 2019).

Table 1 provides an overview of the main Danish secondary and vocational education pathways, highlighting their target groups, age ranges and duration.

Table 1. Comparison of Key Danish Secondary and Vocational Education Pathways (EUD, EUX, and EUV)

Vocational track	*Target group*	*Age range*	*Duration*
EUD	Youth entering vocational education	16–20	3–5 years
EUX	Youth combining vocational training with academic studies	16–20	4–5 years
EUV	Adults returning to education	18+	Flexible

In addition to vocational tracks, Denmark offers five general and technical upper secondary programmes (Andersen & Helms, 2019):

- General Upper Secondary Examination (Danish: Studentereksamen, abbreviated: STX): A three-year academically oriented programme.
- Higher Commercial Examination Programme (Danish: Højere Handelseksamen, abbreviated: HHX): A three-year course combining theoretical studies with practical projects and internships.
- Higher Technical Examination Programme (Danish: Højere Teknisk Eksamen, abbreviated: HTX): A three-year programme emphasizing science and technology within a general education framework.

- Higher Preparatory Examination (Danish, Højere Forberedelseseksamen, Højere Forberedelseseksamen: HF): A two-year programme focused on academic preparation for higher education.
- International Upper Secondary Programmes: These programmes serve international students and follow globally recognised curricula.

While STX and HF serve general education purposes, HHX and HTX are often classified as vocationally oriented due to their applied components (Andersen & Helms, 2019).

Table 2 summarizes the main Danish general upper secondary education programmes, detailing their target groups, age ranges, duration.

Table 2. Overview of Danish General Upper Secondary Education Pathways (STX, HHX, HTX, and HF)

Vocational track	*Target group*	*Age range*	*Duration*
STX	Youth aiming for general academic education	16-19	3 years
HHX	Youth interested in business and economics	16-19	3 years
HTX	Youth interested in science, technology, and engineering	16-19	3 years
HF	Youth seeking a shorter, flexible academic program	17-19	2 years

In addition, the Preparatory Basic Education and Training programme (Danish: Forberedende Grunduddannelse, abbriviated: FGU) programme supports individuals under the age of 25 who have not completed upper secondary education. FGU offers three flexible modules:

- General Basic Education (Danish: Almen Grunduddannelse for Voksne, abbreviated: AGU): This programme is primarily designed for adult learners who need to strengthen their general academic skills. The curriculum is composed of approximately two-thirds theoretical instruction, covering subjects such as Danish, mathematics, English, and social studies, and one-third practical training to support personal development and prepare learners for further education or entry into the labour market.
- Basic Production Education (Danish: Produktionsskolernes Grunduddannelse, abbreviated: PGU): This programme that emphasises hands-on experience in production and vocational environments. It is tailored for adults who require practical skills and workplace orientation before entering formal vocational education programmes. PGU combines practical training with supportive academic instruction as needed, focusing on work readiness and skill development.
- Basic Vocational Education (Danish: ErhvervsGrundUddannelse, abbreviated: EGU): Targeted primarily at young people at risk of leaving traditional education, EGU provides skills training combined with school-based instruction. The programme is flexible and individualised, integrating practical workplace experience with academic support to develop both vocational competencies and basic educational skills, enabling students to progress to formal vocational programmes (EUD/EUX) or directly enter the labour market.

Table 3 presents the main preparatory and alternative vocational education pathways in Denmark, highlighting target groups, age ranges and duration.

Table 3. Overview of Danish Preparatory and Alternative Vocational Pathways (AGU, PGU, and EGU)

Vocational track	*Target group*	*Age range*	*Duration*
AGU	Adults needing basic education	+18	Flexible
PGU	Adults needing vocational preparation	+18	Flexible
EGU	Youth at risk of dropping out of standard education	15-25	1-3 years

The foundation of Denmark's Vocational education and training system lies in the structured combination of academic and work-based learning. Programmes such as EUD typically last 3.5 years, with students alternating between school and company-based training in a 2:1 ratio. The EUX programme introduced a key innovation by combining upper secondary academic qualifications with vocational certification, creating new pathways to tertiary education (Cedefop, 2020).

Since the enactment of the 1989 law (Lov Om Erhvervsuddannelser, 1989), Denmark's vocational education and training programmes have been clearly regulated through national legislation. This law, together with its subsequent amendments, including the 2024 revision, defines VET as dual programmes that alternate between theoretical learning in schools and practical training in companies. According to the legal framework, each VET programme consists of a basic course and a main course, with an optional additional preparatory course for further studies (Act on vocational education and training, 2024).

The basic course is split into two phases: Phase 1 lasts approximately 20 weeks, offering general and vocational orientation. Phase 2 lasts up to additional 20 weeks, focusing on practical preparation for the main course (Cedefop, 2020).

In some cases, the basic course can be replaced entirely or partially by workplace training under a company agreement, a structure known as the New Apprenticeship. Additionally, the Main Course Plus (Danish: Grundforløb Plus, abbrivated GF+) offers a 10-week extension for students who need more time to select a specialisation.

Although the term "Dual Higher Education" is not formally used in Danish legislation, several higher education programmes incorporate both theoretical and practical elements consistent with the principles of dual education. Danish higher education spans ISCED levels 5 to 7 and includes both academic and professionally oriented pathways.

Professional bachelor's programmes, established under legislation since 2008, (Act on academy profession programmes and professional bachelor's programmes, 2008). last between 3 and 4 years. These programmes combine academic learning with mandatory internships of at least six months, equivalent to 30 ECTS credits (Act on academy profession programmes, 2024). Fields include healthcare, pedagogy, business, IT, media, social sciences, technology, and design.

Another key component is Academy Profession (AP) programmes. These full-time programmes last between 1.5 and 2.5 years and include at least three months of compulsory internship. In some disciplines, AP graduates may progress to top-up Professional bachelor's programmes, thereby completing a full bachelor's qualification. These programmes are designed to blend academic knowledge with real-world application, aligning with dual education principles (Act on academy profession programmes, 2024).

Following a Professional Bachelor's degree, students can pursue master's programmes (ISCED level 7), typically two years in duration. These are primarily research-based and focus on advanced theoretical knowledge and practical applications. While internships are not mandatory at master's level, some programmes offer them depending on the discipline. Part-time master's programmes also exist for working professionals who wish to continue their education while employed. (Executive order on part-time professional master's programmes, 2017)

In general, academic bachelor's programmes, students may engage in business projects or select a fully academic curriculum, depending on program design. This flexibility underscores Denmark's broader commitment to integrating theoretical and applied learning across all levels of education.

5 Dual education paths

A 16-year-old student in Denmark is presented with a structured and diversified set of educational pathways upon completion of lower secondary education, reflecting the country's integrated approach to general, vocational, and technical education within the framework of the EQF. The programmes presented are as follows:

- EUD programme: An option of vocational education and training pathway with a duration of approximately three to four years, corresponding to EQF levels 3 to 5. The EUD program is strongly occupation-oriented and is designed to prepare students for direct entry into the labour market within specific economic sectors, including agriculture, commerce, technical trades, and social or health care services. The programme combines school-based instruction with extensive work-based learning and apprenticeships, ensuring that students acquire sector-specific skills aligned with labour market needs.
- EUX programme: This programme also lasts three to four years and corresponds to EQF levels 4 to 5. The EUX program is distinctive in that it integrates general upper secondary education with vocational training in a single, coherent curriculum. Approximately 50% of the programme consists of work-based learning, while the remaining component focuses on general and theoretical subjects. EUX programmes are available primarily in commercial and technical fields and are designed to broaden students' educational opportunities by enabling access to both employment and higher education upon completion.
- HTX program: a three-year upper secondary technical education corresponding to EQF level 4. HTX combines general education with a strong emphasis on technological, scientific, and engineering-related subjects. The curriculum is designed to develop analytical, problem-solving, and innovation-oriented competencies, preparing students primarily for further studies in higher education, particularly within technical and scientific disciplines.
- HHX Program: a three-year programme at EQF level 4. HHX focuses on business, economics, and social sciences, while integrating theoretical instruction with practical elements such as project work, case studies, and internships. This combination aims to equip students with both academic knowledge and practical insight into commercial and organisational contexts.

At the same level of upper secondary and vocational pathways described above, the Danish education system also offers other non-dual upper secondary programes with a duration of two to three years, corresponding to EQF level 4. These programmes are primarily school-based and do not include structured work-based learning or apprenticeship components. Their main objective is to provide students with a general and academic foundation while maintaining permeability within the classical education system. However, graduates of these non-dual programmes are eligible to continue into vocational education and training pathways, as well as to access higher education routes such as Academy Profession programmes, professional bachelor's programmes, and university bachelor's programmes, subject to specific admission requirements.

Upon completion of upper secondary education, typically at the age of 19–20, students may transition to higher education through several pathways. Students holding a general upper secondary qualification, including graduates from general, technical, or equivalent programmes, are eligible to enter a university bachelor's program, which has a standard duration of three years and corresponds to EQF level 6 (The University Act, 2019). University bachelor's programmes are predominantly academic and research-based, with a strong emphasis on theoretical foundations and scientific methodologies. While these programmes are not vocational in nature and do not formally incorporate dual learning models, many include project-based coursework or optional internships that introduce applied and practice-oriented components within an otherwise theoretical framework.

An alternative higher education pathway is the professional bachelor's program, which lasts between three and four years and also corresponds to EQF level 6. Professional bachelor's programmes are explicitly designed to bridge theory and practice by combining academic studies

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with mandatory practical training periods of at least six months. These programmes target professions with clearly defined occupational profiles, such as teaching, nursing, engineering, and social work. Students holding a general or technical upper secondary diploma are eligible for admission, and EUX graduates are also qualified because they have completed both vocational training and general education components.

A third higher education option available to students around the age of 19 is the vocational academy programme. These programmes typically last between 1.5 and 2.5 years and correspond to EQF level 5. Academy Profession programmes are professionally oriented and combine theoretical instruction with applied learning, including a compulsory internship of at least three months. Admission is open to students with either a general upper secondary qualification or an EUD vocational qualification. Furthermore, an Academy Profession degree may serve as a progression route into a related professional bachelor's program (Executive Order on Admission, 2025).

Graduates of the EUD program have direct access to Academy Profession programmes. However, in order to qualify for admission to a professional bachelor's program, EUD graduates are required to complete supplementary upper secondary courses (GS) to ensure that they meet the necessary academic prerequisites (Act on General Upper Secondary Education, 2024). The supplementary secondary courses may last up to four months.

At postgraduate level, students who complete a university bachelor's program (EQF level 6) may continue their studies by enrolling in a master's degree program at EQF level 7. Master's programmes generally have a duration of two years and emphasise advanced scientific and theoretical knowledge, as well as the ability to apply this knowledge in complex, real-world contexts. Although practical components are not legally mandated, some master's programmes include internships, applied projects, or collaboration with industry, depending on the disciplinary field. In addition, part-time master's programmes are available, enabling employed graduates to pursue further qualifications alongside professional activities. Graduates from professional bachelor's programmes may also gain access to master's programmes, subject to the specific admission requirements defined by each institution and field of study.

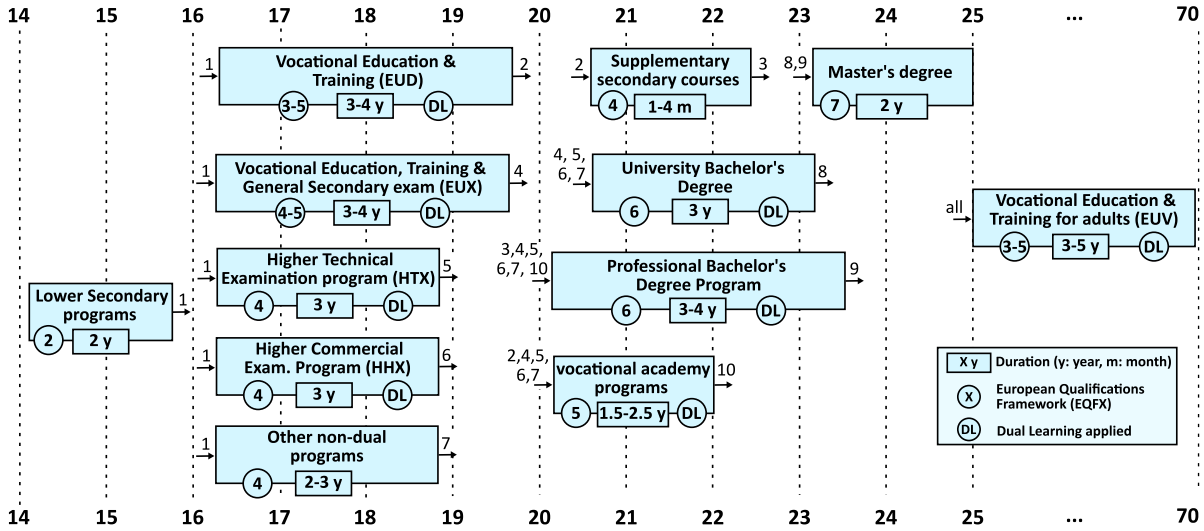

Figure 2. Dual education paths in Denmark's educational system

6 Institutional use cases

The following three institutions were selected as representative use cases because of their active and well-established involvement in dual learning and practice-oriented higher education in Denmark, as well as their institutional diversity within the Danish tertiary education landscape.

Use case 1: Roskilde University (RUC) is a public Danish university founded in 1972 and is internationally recognised for its innovative and student-centred pedagogical model. The university is particularly known for its problem- and project-based learning (PBL) approach, which emphasises

interdisciplinary collaboration, critical thinking, and the application of theoretical knowledge to real-world societal and industrial challenges. RUC hosts approximately 7,000 students enrolled in a broad range of bachelor's and master's programmes across the social sciences, humanities, natural sciences, and technology. Although RUC is not a vocational institution in the strict sense, its strong emphasis on project work, external collaboration, and applied research creates structured opportunities for dual and practice-oriented learning. Students frequently engage in projects developed in cooperation with public institutions, private companies, and non-governmental organisations, thereby strengthening the link between academic education and professional practice.

Use case 2: The University College of Northern Denmark (UCN), established in 2007, is a professionally oriented higher education institution that plays a central role in delivering vocationally relevant tertiary education. UCN offers both Academy Profession programmes and professional bachelor's programmes in key societal and economic fields, including business, social education, health, and technology. The institution is characterised by a strong integration of theoretical instruction with mandatory practical training periods, internships, and close collaboration with regional employers. Dual learning is a core element of UCN's educational model, as curricula are designed in close alignment with labour market needs and professional standards. Through systematic cooperation with industry and public-sector partners, UCN ensures that students acquire occupation-specific competencies and practical experience that enhance employability and facilitate a smooth transition from education to work.

Use case 3: Copenhagen Business Academy (CPH Business) is the largest business academy in Denmark and was founded in 2009 as part of a national reform of short- and medium-cycle higher education. The academy specialises in business-oriented education and offers a wide range of Academy Profession programmes and professional bachelor's programmes within areas such as management, finance, marketing, international trade, and entrepreneurship. CPH Business has a strong focus on applied learning, innovation, and close engagement with the business community. Dual learning is embedded through compulsory internships, company-based projects, and collaboration with both small and medium-sized enterprises and larger organisations. This applied orientation ensures that students develop practical skills alongside theoretical knowledge, while also fostering responsiveness to evolving labour market demands and economic developments.

The three institutional cases illustrate a shared commitment to strengthening the relationship between higher education and professional practice, but they differ significantly in how this integration is structured and institutionalised. Roskilde University represents an academically oriented model, in which engagement with external partners is primarily embedded in project-based and problem-based learning activities. By contrast, the University College of Northern Denmark reflects a highly structured and profession-oriented approach, where internships and workplace learning are mandatory. Copenhagen Business Academy occupies an intermediate position, combining compulsory internships with a strong emphasis on collaboration with industry.

The analysis of the selected use cases was conducted using a questionnaire comprising 34 questions developed to guide the interviews. These questions were grouped into seven analytical criteria, each comprising several indicators that can be assessed using binary yes/no responses. In cases where a question could not be adequately addressed through a binary response, a detailed explanatory footnote was used to capture contextual nuances, institutional specificities, or partial implementations that required further clarification.

The criteria are:

- **Definition:** This criterion it clarifies the conceptual boundaries of dual learning by examining whether it genuinely integrates company-based and school-based learning and whether the resulting qualification represents an educational level beyond upper secondary education.
- **Institutional mission and vision:** This criterion evaluates the strategic commitment of the institution to dual learning, focusing on whether its mission explicitly promotes, coordinates, and sustains dual learning pathways, including the development of dedicated dual bachelor's programmes and the institution's role as a direct operator.

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- **Programme structure:** This criterion examines the formal organisation of dual programmes, with particular attention to the balance between theoretical instruction and practical training, the equivalence of certification with traditional academic models, and alignment with European standards such as the allocation of 180 ECTS credits for bachelor's degrees and the distribution of credits between academic and work-based components.
- **Cooperation with dual partners:** This criterion assesses the depth and quality of collaboration between educational institutions, companies, and public authorities, including the existence of strategic partnerships, continuous communication mechanisms, and the involvement of employers in student selection processes.
- **Admission criteria:** A criterion that focuses on transparency and rigour in entry requirements, specifically whether admission is contingent upon completion of upper secondary education and the formalisation of an apprenticeship or employment contract.
- **Faculty involvement:** This criterion examines the extent to which both internal academic staff and external professionals from industry contribute to teaching and supervision, as well as the academic and professional qualifications of instructors.
- **Student experience:** This criterion it captures the learner-centred dimension of dual learning by evaluating the availability of academic and workplace support structures, the contractual status and remuneration of students, the balance between time spent in the institution and the company, and the presence of systematic feedback and quality assurance mechanisms to support learning outcomes.

Table 4 shows the results obtained when the criteria are applied to RUC, UCN and CPH.

Table 4: Results obtain from the survey send to the three Danish institutions: RUC, UCN and CPH.

		Criteria	*RUC*	*UCN*	*CPH*
Category	*Definition of dual learning*	Is dual learning a combination between company-based and school-based learning?	n/a	Y	Y
		Is the certificate at the end of DHE higher than the high school diploma?	n/a	Y	Y
	Institutional mission and vision	Does the mission focus on promoting and coordinating the organization of the courses for the dual learning?	N	Y	Y
		Is the institution developing teaching and training programs?	N	Y	N
		Does the institution develop dual bachelor's program?	Not directly*	Y	Y
		Is the institution a direct operator?	Y	Y	Y
	Program structure	Is there a combination between practical time in the company and theoretical time in the classroom?	Y	Y	Y
		Is there a certificate similar to the traditional model?	n/a	Y	Y
		Is the total number of ECTS for the bachelor's degree 180?	Y	Y	Y

* bachelor's students have the option to complete a project in collaboration with a company, contributing to the integration of theoretical and practical learning.

	Criteria	RUC	UCN	CPH
	Per year, are credits allocated: 40 for the theoretical part and 20 for the practical part?	N*	n/a	n/a
Cooperation with dual partner	Is there daily contact between the institution and the company?	n/a	n/a	n/a
	Is there a strategic partnership?	Y	Y	Y
	Does the dual partner participate indirectly in student selection?	N	Y	Y
	Is there a contact between the institution and the government?	Y	Y	Y
Criteria of admission	Does the criteria include a certification of higher secondary education?	Y	Y	Y
	Does the criteria include signing an apprenticeship or working contract?	N	n/a	n/a
Faculty Involvement	Are internal and external teachers involved in dual learning process?	Y	n/a	Y
	Do teachers hold bachelor's or master's degree?	Y	Y	Y
	Are external teachers coming from companies?	n/a	n/a	Y
Student' s experience	Is there a support service (supervisors and the reference person in the company)?	n/a	Y	Y
	Is the institution program based on a training/apprenticeship/working contract?	N	Y	Y
	Does the student receive a remuneration?	It depends †	Y	N
	Does the student reside at least 2 days out of a week in the school?	N	Yes but‡	Yes but§
	Is there a feedback mechanism?	n/a	Y	Y

7 Results

The comparison of the three institutions shows that UCN and CPH have clearer structure for dual learning. Both define dual learning as a combination of school-based and company-based training and provide a certificate higher than the high school diploma. By contrast, RUC does not

* The bachelor project is worth 15 to 20 ECTS, and students may complete two in one year, amounting to a total of 30 to 40 ECTS. For the master's programme, the project is worth 10, 15, or 20 ECTS, and a student can apply for a project-based internship.

† For the project-based internship in the Master's programme, the student received a salary that must not exceed 3,375 DKK per month.

‡ The practical part takes the form of an internship during 5 months for the professional bachelor.

§ The practical part takes the form of an internship during 10 at 12 weeks of full-time work for the Academy Profession programmes and for the Professional Bachelor it includes a minimum of 20 weeks of full-time work.

provide sufficient information on this aspect, which makes its dual learning approach less clear. In terms of their missions, UCN and CPH include dual learning as part of their goals. UCN also develops teaching and training programmes, while CPH and RUC do not. All three institutions operate dual learning programmes, but RUC offers dual bachelor's programmes only indirectly, through project-based learning.

All institutions share a similar programme structure, including a balance between practical and theoretical learning and the award of 180 ECTS credits for a bachelor's degree. UCN and CPH offer a certificate similar to the traditional model, while this is not confirmed for RUC because of a lack of available information. When it comes to cooperation with companies, all three have strategic partnerships and maintain contact with the government. However, only UCN and CPH involve companies in the student selection process. This indicates that UCN and CPH have stronger cooperation with the dual learning partners, while RUC has less involvement from external stakeholders.

In terms of admission, all three institutions require a higher secondary education diploma. RUC is the only one that clearly states it does not require a working or apprenticeship contract. UCN and CPH do not provide information on this point. Regarding faculty, all institutions confirm that their teachers hold at least a bachelor's or master's degree. RUC and CPH involve both internal and external teachers, but only CPH clearly involves teachers from companies, indicating a stronger link to industry.

Student experience is more structured at UCN and CPH. Both provide support services, feedback mechanisms, and programmes based on training or work contracts. Students at UCN receive payment, while CPH does not provide remuneration. RUC offers payment only in specific cases during master's internships. RUC also does not require students to stay at school for part of the week, unlike UCN and CPH. This suggests that UCN and CPH offer a more complete and more supportive environment for students in dual learning programmes.

8 Conclusion

Denmark's approach to Dual Higher Education appears to be grounded in a strong legal and institutional framework. Since the Apprenticeship Act of 1956, the Danish Vocational education and training system has expanded from a traditional apprenticeship model to a diversified structure offering multiple vocational and academic pathways. These developments are formally defined and regulated through national legislation, particularly the VET law of 1989 and its later amendments, including the most recent amendment in 2024. This legal framework defines VET as a dual model combining school-based learning with company-based training. While the term "Dual Higher Education" is not explicitly used in law, several higher education programmes follow the dual model in practice.

The structure of the Danish education system offers multiple learning paths that allow students to move between vocational and academic tracks. From the age of 16, students can choose from vocational or general upper secondary programmes, with options such as EUD, EUX, HTX, and HHX, each leading to distinct but interconnected higher education routes. The system allows progression from vocational training to higher vocational education, such as Academy Profession or professional bachelor's programmes, and even to university-level education. This layered and open structure facilitates the integration of dual learning at multiple stages in response to students' interests and labour market demands.

Based on the analysis, several potentially transferable practices can be identified. First, integrating dual learning into a university's mission and strategic planning may help align resources and objectives. Building strong partnerships with companies appears to be important, not only for providing practical placements but also for involving industry in curriculum design and student selection, which strengthens the relevance of education to labour market needs. In addition, offering structured student support, including training contracts, regular school attendance, and access to mentors, may improve learning outcomes and satisfaction.

Finally, it should be noted that the findings of this study are based on the analysis of policy documents and a limited number of institutional cases. As such, they do not provide a

comprehensive representation of the Danish higher education system, but rather illustrate selected and emerging approaches to integrating elements of dual higher education.

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European Scientific Journal for Dual Higher Education

Vol. 2, No. 1, (2026)
ISSN (online): 3052-7015

THE ROLE OF DUAL EDUCATION PROGRAMMES IN SMART SPECIALISATION STRATEGIES: THE CASE OF MONDRAGON UNIBERTSITATEA'S FACULTY OF ENGINEERING

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Keywords:
Dual education programmes
Mobility of students
Knowledge transfer
Entrepreneurial university
Smart Specialisation Strategies

Article history:
Received: 15 January 2026
Revised: 13 April 2026
Accepted: 14 April 2026

Abstract
Universities have become key actors within regional innovation ecosystems through their roles in knowledge transfer, talent development, and industry collaboration. Dual education programmes, particularly at undergraduate level, enhance practical learning, facilitate the transition to employment, and reinforce university-industry engagement. In the Basque Country, the Smart Specialisation Strategy (S3) prioritises smart manufacturing, cleaner energy, and personalised health, relying on universities to advance these domains through structured learning and applied research. However, limited empirical evidence exists on the contribution of Bachelor's (BT) and Master's (MT) theses conducted in companies. This study examines BT/MT projects at MGEP and reveals stronger BT alignment with S3, especially in smart manufacturing, as well as consistent alignment across provinces.

1 Introduction

The literature underscores the need for regional innovation strategies to build competitive advantages, although the concept remains imprecise when applied territorially. The European Commission promotes Smart Specialisation Strategies (S3) as a concrete territorial approach (McCann & Ortega-Argilés, 2018).

The relationship between university-industry collaboration (UIC) and S3 is multifaceted. While S3 seeks to strengthen regional innovation capacities, its implementation can create tensions, including reduced research investment and weakened UIC (Mascarenhas et al., 2022). However, when aligned with S3 priorities, UIC enhances knowledge transfer and innovation (Mascarenhas et al., 2022). Broader technological diversification also calls for rethinking university-industry dynamics (Calza et al., 2019). Universities play a central role in regional development, especially in peripheral regions, as illustrated by the Region Värmland-Karlstad University partnership (Kempton, 2015).

Regional Innovation Strategy (RIS3) provides a framework for aligning research and innovation with regional priorities. In the Basque Country, these include smart manufacturing, cleaner energy, and personalised health (Euskadi, 2020). The success of this strategy depends on active university engagement in talent development and knowledge transfer (Burbridge & Morrison, 2021).

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Within this framework, student mobility through Bachelor's (BT) and Master's Thesis (MT) collaborations represents a key channel for transferring academic knowledge to industry. However, empirical evidence on how such structured mobility supports RIS3 remains limited.

This study examines how Mondragon Unibertsitatea's Faculty of Engineering (MGEP) contributes to RIS3 through BT and MT projects developed with companies. We analyse their alignment with strategic priorities while exploring differences between BT and MT, territorial patterns across Gipuzkoa, Bizkaia, and Araba, temporal trends, and the relationship between degree specialisation and RIS3 domains. Ultimately, the study advances understanding of how student thesis projects support RIS3 areas (advanced manufacturing, energy, and health) and reinforce universities' role as active regional innovation agents. Specifically, this paper aims to answer the following research questions: (i) How are BT and MT projects distributed by year? (ii) Which degree or master's programmes produce the highest number of projects? (iii) Which provinces have the highest concentration of projects? (iv) To what extent is the concentration of projects driven by regional business density? (v) What percentage of projects are aligned with S3 areas? and (vi) With which strategic area are S3 projects aligned?

2 Literature review

The relationship between Regional Innovation Strategy (RIS3) and Smart Specialisation Strategies (S3) is closely intertwined, with RIS3 serving as a prerequisite for EU regions to receive funding for research and innovation (Panori et al., 2017). Both approaches share common ground in fostering regional innovation, with RIS3 building upon experiences from cluster policies (Aranguren & Wilson, 2013). The implementation of RIS3 requires a shift from plans to processes, emphasising the importance of leadership and an entrepreneurial discovery process (Wilson et al., 2015). The success of RIS3 policies is heavily dependent on the capacity of regional government institutions to coordinate and facilitate interventions, with sound institutional frameworks playing a crucial role in innovation processes (Rodríguez-Pose et al., 2014). These strategies aim to support science, technology, and innovation investments where there are clear synergies with existing productive capacities and capabilities, ultimately driving regional development and innovation (Aranguren & Wilson, 2013).

2.1 The Basque country's regional innovation Strategy and Smart Specialisation strategy

RIS3 is defined as a set of interactive networks that foster innovation through localised learning and knowledge transfer (Ferretti & Parmentola, 2015; Stoimenova, 2019). These strategies emphasise regional engagement and stakeholder interaction to enhance innovation capabilities and have been promoted by the European Commission to boost competitiveness (Stoimenova, 2019). However, integrating RIS3 with other policies, such as Responsible Research and Innovation (RRI), remains challenging due to differences in scale and perspectives (Fitjar et al., 2019). Although applied in Europe, the United States, Japan, and Korea (Lim, 2006), ambiguity persists regarding their definition and implementation (Ferretti & Parmentola, 2015).

The Basque Country's regional innovation system has driven structural change and competitiveness through technological centres and targeted policies reducing reliance on traditional industries (López-Rodríguez et al., 2010). These efforts positioned the region as a leader in R&D&i investment and innovative firms (López-Rodríguez et al., 2010).

S3, initially an academic concept, has become central to EU regional policy, although it faces methodological and governance challenges (Foray et al., 2011; Griniece et al., 2017). Ferreira et al. (2025) highlight their systemic potential, while Hassink & Gong (2021) critique reliance on traditional science and technology models.

The Basque Country exemplifies effective S3 implementation, supported by flexible governance (Navarro et al., 2011) and continuity in development strategies (Arancegui, 2015). S3 Euskadi builds on diversified specialisation, leveraging enabling technologies (advanced manufacturing, bioscience, and nanoscience) and five priority markets (Euskadi, 2020) (Figure 1). Success depends on collaborative governance and adaptive leadership (Aranguren et al., 2015).

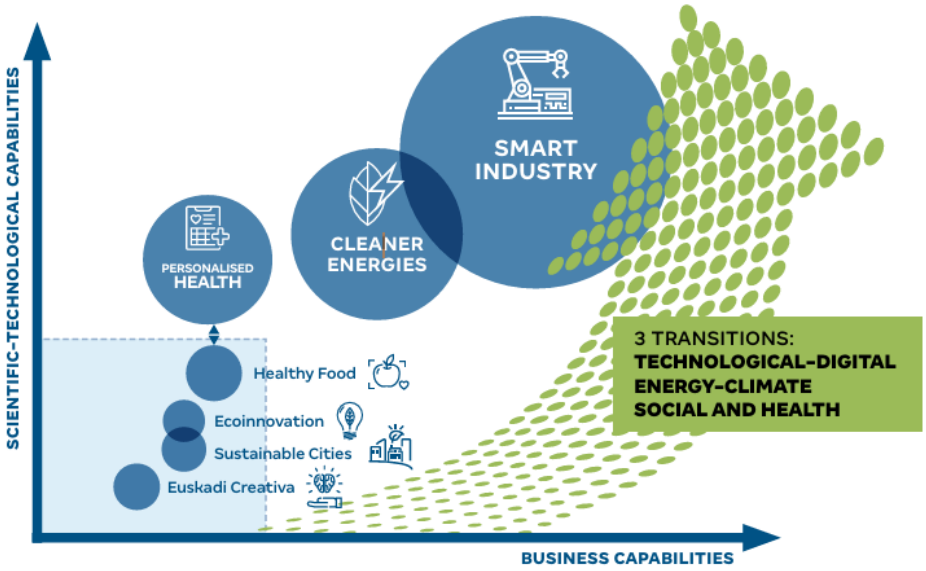

Figure 1. The Basque Country's Smart Specialisation Strategy (Euskadi, 2020)

The Basque experience underscores the importance of institutional frameworks, experimental processes, and broader stakeholder engagement, including SMEs and civil society (Aranguren & Magro, 2022; Morgan et al., 2020).

2.2 University-industry collaboration activities: student mobility

University-Industry Collaboration (UIC) constitutes a foundational element of contemporary innovation ecosystems, facilitating knowledge co-creation, technological development, and regional economic growth. It is broadly understood as the interaction between higher education institutions and non-academic organisations to exchange and generate knowledge and technology (Ankrah & Al Tabbaa, 2015; Bekkers & Freitas, 2008; Siegel et al., 2003). UIC encompasses a diverse set of direct and indirect collaborative activities extending beyond research (Davey et al., 2011, 2018), with "business" construed as including all non-academic actors (Clauss & Kesting, 2017).

The literature presents multiple conceptualisations of UIC: cooperative R&D partnerships between universities and firms (Bozeman et al., 2013; Perkmann & Walsh, 2007; Petruzzelli, 2011); a mechanism supporting the transition to a knowledge-based society (Ranga & Etzkowitz, 2013); bidirectional linkages enabling the diffusion of ideas, skills, and human capital (Plewa et al., 2013); interorganisational exchanges of tangible and intangible resources (Perkmann et al., 2013); and processes generating novel knowledge for both partners (Hardy et al., 2003). Such definitions reflect the breadth of UIC practices, ranging from intellectual property licensing to collaborative R&D (Gulbrandsen et al., 2011).

Informal interactions, driven by personal ties and geographical or social proximity, are recognised for their positive impact on local industry (Breschi & Lissoni, 2001), although their interplay with formal UIC remains underexamined. Formal interactions, typically contract-based, exhibit substantial heterogeneity (Bekkers & Freitas, 2008) and closely align with universities' core missions of education, research, and valorisation (Galan-Muros & Davey, 2017). While patents, licences, and academic entrepreneurship have dominated scholarly attention (Agrawal & Henderson, 2002; Isaksen & Karlsen, 2010; Laukkanen, 2003; Lehmann & Menter, 2016; O'shea et al., 2005; Phan & Siegel, 2006; Rothaermel et al., 2007; Shane, 2004), evidence indicates that the scope of UIC is considerably broader (Davey et al., 2018; Mascarenhas et al., 2025).

Education-oriented collaboration, particularly work-integrated learning (WIL), has gained prominence as an avenue for strengthening university-industry collaboration (UIC) by providing students with practical experience, facilitating their transition to professional contexts, and narrowing

the cultural and structural gaps between academia and firms (Rampersad, 2015). This practical engagement aligns with recent literature emphasising that student mobility is emerging as a critical strategic pillar within regional innovation frameworks, acting as a primary conduct for 'knowledge spillovers' between universities and regional industries (Mascarenhas et al., 2025). By embedding students within industrial networks, WIL not only facilitates the flow of tacit knowledge but also addresses the structural gaps identified in S3, where leading research institutions and private firms often remain separated (Rodríguez Ochoa et al., 2025).

The choice of UIC activity is shaped by the nature of the knowledge exchanged (Bekkers & Freitas, 2008) and firms' absorptive capacity (Agrawal & Henderson, 2002; Hewitt-Dundas, 2013). Early-stage, low-commitment collaborations such as guest lecturing contrast with resource-intensive joint R&D typical of mature partnerships (Alunurm et al., 2020; De Man, 2004).

Academic classifications frequently distinguish between "soft" activities - consultancy, training, and the provision of skilled graduates - and "hard" activities, including patenting, licensing, and spin-off creation (Perkmann & Walsh, 2007; Philpott et al., 2011). Among the most comprehensive typologies is that proposed by Davey et al. (2018), which consolidates the principal UIC mechanisms identified in the literature (Table 1).

Table 1. Classification of UIC activities by domain (Davey et al., 2018)

UIC domains	*UIC activities*
Education	- Mobility of students
	- Curriculum co-design
	- Curriculum co-delivery
	- Dual education programs
	- Lifelong learning for people from business
Research	- Joint R&D
	- Consultancy for business
	- Mobility of staff
Valorization	- Commercialization of R&D results
	- Academic entrepreneurship
	- Student entrepreneurship
Management	- Governance
	- Shared resources
	- Industry support

Within the education domain of UIC, student mobility has become a central mechanism for knowledge exchange and for aligning higher education with labour market needs. Recognised as one of the eight core UIC domains, it contributes to academic entrepreneurship and human capital development (Dima A. M., 2017). From an enterprise perspective, mobility enhances innovation capacity and narrows the gap between theoretical and practical knowledge (Pavlin, 2016), while also strengthening trust-based partnerships and improving employability outcomes (Rudawska & Kowalik, 2019).

Student mobility is also identified as a channel for commercialising academic knowledge and addressing industry skill shortages (Treasury, 2003). Structured initiatives such as Erasmus+ show how mobility strengthens business education and fosters cross-border institutional collaboration (Mihaylova et al., 2024). Overall, the literature emphasises that mobility is not merely an educational practice but a strategic component of UIC, supporting innovation, workforce readiness, and internationalisation.

3 Methodology

A single-case study approach was chosen to understand how student mobility contributes to the Basque Country's S3. Case studies specifically emphasise contextual understanding (Saunders et al., 2009). Therefore, Mondragon Unibertsitatea's Faculty of Engineering (MGEP) serves as an exemplary case through which to explore how Bachelor's thesis (BT) and Master's thesis (MT) projects can support Basque Country's S3.

Mondragon Unibertsitatea stands out as a benchmark in knowledge transfer, ranking third among Spanish universities in this dimension according to the 2025 U-Multirank results. This recognition reflects its strong commitment to applied research and close collaboration with industry, particularly through dual education models, final projects developed within companies, and a high rate of graduates working in the surrounding region. The university also excels in attracting external research funding, further reinforcing its role as a key driver of innovation and regional development.

3.1 Case study overview

MGEP is a cooperative faculty strongly committed to social transformation, reflected in its participatory governance model. It forms part of MONDRAGON Corporation, a diversified business group operating in finance, industry, retail, and knowledge sectors (Arregui, 2006). MONDRAGON Corporation is currently the largest business group in the Basque Country and the tenth largest in Spain, comprising 95 autonomous cooperatives, around 80,000 employees, and 14 R&D centres. Within its knowledge area, Mondragon University plays a central role. Officially recognised by Law 4/1997, the university was founded through the association of three educational cooperatives: MGEP, the Faculty of Business Studies, and the Faculty of Humanities and Education Sciences. In 2011, the Faculty of Gastronomic Sciences (Basque Culinary Centre) joined the university.

MGEP has more than 50 years of experience adapting its educational model to changing socio-economic contexts. A cornerstone of this model is the dual education programme, which provides in-company learning through different formats adapted to student needs. The programme has been continually refined to meet national and European standards, address industry demands, and ensure a high-quality learning experience. Implemented across nine bachelor's and nine master's degrees, it engages around 800 students annually in collaboration with more than 200 companies. MGEP promotes long-term apprenticeships structured in two stages: an optional first stage during the 2nd-3rd years of the bachelor's degree and the 1st year of the master's, combining part-time study and work; and a compulsory second stage consisting of full-time Bachelor's/Master's Thesis Projects designed to bridge academic learning and professional practice.

3.2 Participants and data collection

The study is based on the analysis of dual education projects from 2020 to 2024 at MGEP, for the nine bachelor's degrees and nine master's degrees offered by the faculty. It adopts a mixed-method approach to analyse the impact of BT and MT projects on regional innovation and knowledge transfer. The research design consists of the following steps:

1. Data collection: a dataset comprising BT/MT projects completed at MGEP from 2020 to 2024, categorised by level of study and discipline, sector, company, and research focus. A total of 2,224 projects were developed in 1,328 companies located in the Basque Autonomous Community (BAC) and engaged in several types of activities.
2. Classification of these projects according to the S3 priority sectors and other non-S3 sectors, using CNAE-2009 classification.
3. Critical analysis of project titles and descriptions using keywords linked to the RIS3 sectors, for projects developed in companies whose main CNAE code was not classified as belonging to S3.

3.3 Data processing and analysis

The statistical analysis was conducted using IBM SPSS Statistics software (version 31.0.0.0), which enabled both descriptive and inferential examination of the dataset comprising 2,224 BT and MT projects developed between 2020 and 2024. Projects were first classified according to the S3 strategic sectors using the CNAE-2009 code and keyword-based content analysis. Descriptive statistics were used to explore distributions across academic programmes, provinces, and S3 alignment. To assess relationships and differences, several inferential tests were applied:

independent samples t-tests evaluated the alignment of BT versus MT projects with S3 priorities; chi-square tests examined associations between thesis type, academic program, and S3 sectors; and one-way ANOVA was used to test temporal trends in S3 alignment. Effect sizes such as Cohen's d and eta squared were calculated to determine the practical significance of findings.

4 Results

The findings are divided into two sections. Section 4.1 thoroughly describes the characteristics of MGEP's BT and MT projects: year distribution, degree distribution, geographical distribution and alignment with S3 areas. Section 4.2 presents the findings from the statistical analysis used to address the research questions.

4.1 Descriptive statistics

To evaluate the contribution of student mobility projects to the Basque Country's S3, this section presents a detailed descriptive statistical analysis of 2,224 BT and MT projects developed at MGEP between 2020 and 2024. The descriptive analysis responds to several key questions: (i) How are BT and MT projects distributed by year? (ii) Which degree or master's programmes produce the highest number of projects? (iii) Which provinces have the highest concentration of projects? (iv) To what extent is the concentration of projects driven by regional business density? (v) What percentage of projects are aligned with S3 areas? and (v) With which strategic area are S3 projects aligned? (vi) Are S3 Strategic Areas Driven by Company Activity? These questions guide the exploration of patterns in academic engagement with regional innovation priorities.

4.1.1 How are BT and MT projects distributed by year?

This subsection presents a descriptive analysis of the distribution of BT and MT theses from 2020 to 2024 (Table 2). The results show a steady increase in the number of BT projects over the years, rising from 245 in 2020 to 307 in 2024. In contrast, the number of MT projects has remained relatively stable, fluctuating slightly between 151 and 174 annually. Overall, BTs consistently outnumber MTs each year.

Table 2. Distribution of BT and MT projects by year

			BT1_MT2		*Total*
			1	*2*	
YEAR	2020	Count	245	158	403
		% within BT1_MT2	17,4%	19,4%	18,1%
	2021	Count	256	164	420
		% within BT1_MT2	18,2%	20,1%	18,9%
	2022	Count	295	151	446
		% within BT1_MT2	21,0%	18,5%	20,1%
	2023	Count	305	174	479
		% within BT1_MT2	21,7%	21,3%	21,5%
	2024	Count	307	169	476
		% within BT1_MT2	21,8%	20,7%	21,4%
Total		Count	1408	816	2224
		% within BT1_MT2	100,0%	100,0%	100,0%

4.1.2 Which degree or master's programmes produce the highest number of projects?

The distribution of projects by degree and master's programme shows that the highest number of projects were generated by programme GM, followed by MH, GD, and GO (Table 3). These four programmes alone account for a significant portion of the total 2,224 projects. In contrast, programmes such as MS, ML, and MM contributed the fewest projects.

Table 3. Distribution of BT and MT projects by degree

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	GA (Energy Engineering)	97	4,4	4,4	4,4
	GB (Biomedical Engineering)	86	3,9	3,9	8,2
	GC (Eco-technology in Industrial Processes Engineering)	67	3,0	3,0	11,2
	GD (Industrial Design and Product Development Engineering)	242	10,9	10,9	22,1
	GE (Industrial Electronics Engineering)	151	6,8	6,8	28,9
	GJ (Mechatronics Engineering)	192	8,6	8,6	37,5
	GM (Mechanical Engineering)	348	15,6	15,6	53,2
	GO (Engineering in Industrial Organizations)	225	10,1	10,1	63,3
	MD (Strategic Design of Products and Services)	62	2,8	2,8	66,1
	MG (Energy and Power Electronics)	83	3,7	3,7	69,8
	MH (Industrial Engineering)	265	11,9	11,9	81,7
	MIP (Business Innovation and Project Management)	98	4,4	4,4	86,2
	ML (Supply chain, Manufacturing and Logistics Management)	30	1,3	1,3	87,5
	MM (Biomedical Technologies)	57	2,6	2,6	90,1
	MN (Data Analysis, Cybersecurity and Cloud Computing)	64	2,9	2,9	92,9
	MR (Robotics and Control Systems)	135	6,1	6,1	99,0
	MS (Smart Energy Systems)	22	1,0	1,0	100,0
	Total	2224	100,0	100,0	

4.1.3 Which provinces have the highest concentration of projects?

The distribution of projects by province (Table 4) reveals a strong concentration in Gipuzkoa, which accounts for 82.5% of all projects. Bizkaia follows with 12.5%, while Araba contributes only 5% of the total. This indicates a significant geographic imbalance, with Gipuzkoa being the dominant location for project development.

Table 4. Distribution of BT and MT projects by province

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	ARABA	111	5,0	5,0	5,0
	BIZKAIA	279	12,5	12,5	17,5
	GIPUZKOA	1834	82,5	82,5	100,0
	Total	2224	100,0	100,0	

4.1.4 To what extent is the concentration of projects driven by regional business density?

To examine the relationship between the type of project (BT/MT) and its geographic distribution across provinces (Araba/Bizkaia/Gipuzkoa), a Pearson correlation analysis was conducted (Table 5). The results indicate a statistically significant, although very weak, positive correlation between the variables ($r = 0.046$, $p = 0.030$). These findings were further validated by a Spearman's rho non-parametric test ($rs = 0.045$, $p = 0.033$), confirming that while a geographical pattern exists, it explains only a small fraction of the total variance (Table 7). This suggests that project placement is likely driven by a more complex set of factors beyond mere provincial business density, such as specific industry specialisations or academic degree requirements.

Table 5. Pearson correlation analysis

		BT1_MT2	*PROVINCE_123*
BT1_MT2	Pearson Correlation	1	,046*
	Sig. (2-tailed)		,030
	N	2224	2224
PROVINCE_123	Pearson Correlation	,046*	1
	Sig. (2-tailed)	,030	
	N	2224	2224

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6. Spearman's correlation analysis

			BT1_MT2	PROVINCE_123
Spearman's rho	BT1_MT2	Correlation Coefficient	1,000	,045*
		Sig. (2-tailed)	.	,033
		N	2224	2224
	PROVINCE_123	Correlation Coefficient	,045*	1,000
		Sig. (2-tailed)	,033	.
		N	2224	2224

*. Correlation is significant at the 0.05 level (2-tailed).

4.1.5 What percentage of projects are aligned with S3 areas?

58.7% of the projects are aligned with the strategic areas of S3, while 41.3% are not (Table 7). This indicates that most of the final projects developed over the past years are connected to the smart specialisation priorities of the Basque Country. The high level of alignment suggests a strong integration between academic work and regional innovation strategies, which may reflect institutional efforts to promote collaboration with key sectors and enhance the relevance of student projects.

Table 7. Distribution of BT and MT projects by S3 alignment

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	NO	918	41,3	41,3	41,3
	YES	1306	58,7	58,7	100,0
	Total	2224	100,0	100,0	

4.1.6 With which strategic area are S3 projects aligned?

The dataset reveals that, out of a total of 2,224 projects, approximately 59% (1,306 projects) are explicitly aligned with one or more S3 areas (Table 8). The most prominent sector is Smart Manufacturing, accounting for 35.7% of all projects, indicating a strong regional emphasis on advanced industrial technologies. Other notable sectors include Bio/Health (7.8%), Bio & Smart Manufacturing (6.2%), and Energy & Smart Manufacturing (4.2%), reflecting a growing interest in cross-sectoral innovation. A significant portion of projects (41.3%) falls under the "Valid" category, which may represent initiatives that are relevant but not yet categorised into specific S3 sectors.

Table 8. Distribution of BT and MT projects by S3 area

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid		918	41,3	41,3	41,3
	Bio & SM	137	6,2	6,2	47,4
	Bio/Health	173	7,8	7,8	55,2
	Energy	82	3,7	3,7	58,9
	Energy & Bio	15	,7	,7	59,6
	Energy & Bio & SM	12	,5	,5	60,1
	Energy & SM	93	4,2	4,2	64,3
	Smart Manufacturing	794	35,7	35,7	100,0
	Total	2224	100,0	100,0	

4.1.7 Are S3 strategic areas driven by company activity?

To evaluate the strategic alignment between regional innovation priorities and industrial reality, a Chi-square test of independence was performed between the S3 Strategic Areas and the companies' CNAE sectors (N = 1,301). The analysis revealed a highly significant association between the variables ($\chi^2 = 1449.11$, df = 714, $p < .001$). The strength of this relationship, measured by Cramer's V (.431), indicates a robust moderate-to-strong association, suggesting that project distribution is not random but closely follows the specialised domains of the Basque Country's industrial fabric (Table 9). These results provide empirical evidence that the student projects are effectively clustered within specific S3 axes according to the specialised activity of the host companies, confirming a high degree of practical alignment with the regional Smart Specialisation Strategy.

Table 9. Chi-square test of S3 strategic areas versus company activity

	Cases					
	Valid		*Missing*		*Total*	
	N	*Percent*	*N*	*Percent*	*N*	*Percent*
RIS3_StrategicAreas * CNAE2009	1301	58,5%	923	41,5%	2224	100,0%

Chi-Square Tests

	Value	*df*	*Asymptotic Significance (2-sided)*
Pearson Chi-Square	1449,107[a]	714	<,001
Likelihood Ratio	1107,025	714	<,001
Linear-by-Linear Association	,878	1	,349
N of Valid Cases	1301		

a. 791 cells (94,2%) have expected count less than 5. The minimum expected count is ,01.

Symmetric Measures		*Value*	*Approximate Significance*
Nominal by Nominal	Phi	1,055	<,001
	Cramer's V	,431	<,001
N of Valid Cases		1301	

4.2 Research questions

Building on the descriptive analysis, this section presents the core research questions that guide the inferential analysis of student mobility projects within the framework of the Basque Country's Smart Specialisation Strategy. The aim is to examine whether specific characteristics of academic engagement (such as project type, academic programme, geographic location, and period) are significantly associated with S3 alignment. The following questions structure this inquiry: (RQ1) Which student mobility activity (BT or MT) is more closely related to S3 projects? (RQ2) Is there an association between the type of student mobility activity (BT or MT) and alignment with S3 strategic areas? (RQ3) Do the provinces of Gipuzkoa, Bizkaia, and Araba differ in the proportion of projects aligned with RIS3 areas? (RQ4) Are there significant differences in the number of S3-aligned projects across different academic years? and (RQ5) Is there a significant relationship between the type of university degree and the S3 strategic areas in which graduates are positioned?

4.2.1 RQ1. Which student mobility activity - Bachelor's thesis (BT) or Master's thesis (MT) - is more closely related to RIS3 projects?

An independent samples t-test was conducted to examine whether the proportion of S3-aligned projects differed between undergraduate (BT) and master's (MT) programmes. The results revealed a statistically significant difference between the two groups, $t(2222) = 6.692$, $p < .001$. BT projects had a higher proportion of RIS3 alignment ($M = 0.64$, $SD = 0.48$) compared to MT projects ($M = 0.50$, $SD = 0.50$). The mean difference was 0.144, with a 95% confidence interval ranging from

0.102 to 0.186. The effect size, measured by Cohen's d, was 0.488, indicating a moderate practical significance (Table 10). These findings suggest that undergraduate programmes are more likely to produce S3-related projects than master's programmes.

Table 10. t-test analysis for RQ1

	BT_MT	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
S3_Yes1No0	BT	1408	,64	,480	,013
	MT	816	,50	,500	,018

Independent Samples Test

		t-test for Equality of Means							
		t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
				One-Sided p	Two-Sided p			Lower	Upper
S3_Yes1No0	Equal variances assumed	6,692	2222	<,001	<,001	,144	,021	,102	,186
	Equal variances not assumed	6,620	1645,847	<,001	<,001	,144	,022	,101	,186

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
S3_Yes1No0	Cohen's d	,488	,294	,208	,381
	Hedges' correction	,488	,294	,208	,381
	Glass's delta	,500	,287	,200	,374

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

4.2.2 RQ2. Is there an association between the type of student mobility activity (BT or MT) and alignment with S3 strategic areas?

A Chi-square test was conducted to examine the relationship between the type of student mobility activity (BT or MT) and the S3 strategic sectors in which these projects are developed. The results revealed a statistically significant association between thesis type and S3 sector (χ^2 = 122.317, df = 6, $p < 0.001$), indicating that the distribution of BT and MT projects is not uniform across sectors (Table 11). Specifically, BT projects are more prevalent in sectors such as Smart Manufacturing and Bio/Health, while MT projects are more concentrated in Energy-related areas.

Table 11. Chi-square test for RQ2

			S3_SECTOR								Total
				Bio & SM	Bio/Health	Energy	Energy & Bio	Energy & Bio & SM	Energy & SM	Smart Manufacturing	
BT_MT	BT	Count	507	101	49	52	3	12	79	605	1408
		% within S3_SECTOR	55,2%	73,7%	28,3%	63,4%	20,0%	100,0%	84,9%	76,2%	63,3%
	MT	Count	411	36	124	30	12	0	14	189	816
		% within S3_SECTOR	44,8%	26,3%	71,7%	36,6%	80,0%	0,0%	15,1%	23,8%	36,7%
Total		Count	918	137	173	82	15	12	93	794	2224
		% within S3_SECTOR	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	217,940[a]	7	<,001
Likelihood Ratio	224,030	7	<,001
N of Valid Cases	2224		

a. 1 cells (6,3%) have expected count less than 5. The minimum expected count is 4,40.

4.2.3 RQ3. Do the provinces of Gipuzkoa, Bizkaia, and Araba differ in the proportion of projects aligned with S3 areas?

A Chi-square test of independence was conducted to examine whether the proportion of S3-aligned projects differed significantly across provinces. The results showed no statistically significant association between province and S3 alignment ($\chi^2 = 1.67$, $p = 0.434$) (Table 12). This indicates that, although Gipuzkoa hosts most projects in absolute terms, the relative proportion of S3-aligned projects is similar across Araba, Bizkaia, and Gipuzkoa. Therefore, RIS3 alignment appears to be consistent across geographic location.

Table 12. Chi-square test for RQ3

			S3_YesNo		*Total*
			NO	*YES*	
PROVINCE	ARABA	Count	50	61	111
		% within S3_YesNo	5,4%	4,7%	5,0%
	BIZKAIA	Count	107	172	279
		% within S3_YesNo	11,7%	13,2%	12,5%
	GIPUZKOA	Count	761	1073	1834
		% within S3_YesNo	82,9%	82,2%	82,5%
Total		Count	918	1306	2224
		% within S3_YesNo	100,0%	100,0%	100,0%

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1,671[a]	2	,434
Likelihood Ratio	1,673	2	,433
N of Valid Cases	2224		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 45,82.

4.2.4 RQ4. Are there significant differences in the number of S3-aligned projects across different academic years?

A one-way ANOVA was conducted to examine whether the proportion of S3-aligned projects varied significantly across the period 2020-2024 (Table 13). The descriptive statistics showed a slight decrease in S3 alignment over time, with the highest proportion in 2020 (M = 0.62) and the lowest in 2023 and 2024 (M = 0.57). However, the ANOVA results indicated no statistically significant differences between years, F (4, 2219) = 0.874, p = .479. The effect size was negligible ($\eta^2 = 0.002$), suggesting that the year of the project had minimal influence on S3 alignment. Therefore, we conclude that the proportion of S3-related projects remained relatively stable over the five-year period.

Table 13. One-way ANOVA for RQ4

S3_Yes1No0

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
2020	403	,62	,485	,024	,58	,67	0	1
2021	420	,59	,493	,024	,54	,63	0	1
2022	446	,59	,492	,023	,55	,64	0	1
2023	479	,57	,495	,023	,53	,62	0	1
2024	476	,57	,496	,023	,52	,61	0	1
Total	2224	,59	,492	,010	,57	,61	0	1

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
S3_Yes1No0	Based on Mean	3,961	4	2219	,003
	Based on Median	,874	4	2219	,479
	Based on Median and with adjusted df	,874	4	2218,490	,479
	Based on trimmed mean	3,961	4	2219	,003

ANOVA

S3_Yes1No0

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,848	4	,212	,874	,479
Within Groups	538,229	2219	,243		
Total	539,077	2223			

ANOVA Effect Sizes[a,b]

		Point Estimate	95% Confidence Interval	
			Lower	Upper
S3_Yes1No0	Eta-squared	,002	,000	,005
	Epsilon-squared	,000	-,002	,003
	Omega-squared Fixed-effect	,000	-,002	,003
	Omega-squared Random-effect	,000	,000	,001

a. Eta-squared and Epsilon-squared are estimated based on the fixed-effect model.
b. Negative but less biased estimates are retained, not rounded to zero.

4.2.5 RQ5. Is there a significant relationship between the type of university degree and the S3 strategic areas in which graduates are positioned?

The analysis indicates a statistically significant relationship between the type of university degree and the S3 strategic areas in which graduates are positioned (Table 14), as evidenced by the Pearson chi-square value of 1404.224 (df = 96, p < .001). This indicates that the distribution of graduates across strategic areas is not random but varies meaningfully depending on their degree.

Graduates with degree GA are predominantly positioned in the "Energy & Bio" and "Smart Manufacturing" areas, while degree GB graduates are mainly found in "Energy" and "Energy & SM". Degrees such as GD and GM show strong representation in the "Energy" area, whereas GE and

MH are more evenly distributed across multiple strategic areas, including "Bio/Health" and "Bio & SM". These patterns suggest that certain degrees are more aligned with specific S3 priorities, highlighting the importance of academic background in shaping graduates' strategic positioning within innovation ecosystems.

Table 14. Chi-square test for RQ5

			S3_StrategicAreas							*Total*
			Bio & SM	Bio/Health	Energy	Energy & Bio	Energy & Bio & SM	Energy & SM	Smart Manufacturing	
DEGREE	GA	Count	5	1	22	0	56	0	8	92
		% within S3_StrategicAreas	6,1%	0,6%	2,8%	0,0%	60,2%	0,0%	66,7%	7,0%
	GB	Count	0	0	23	0	0	62	1	86
		% within S3_StrategicAreas	0,0%	0,0%	2,9%	0,0%	0,0%	45,3%	8,3%	6,6%
	GC	Count	0	0	54	0	3	8	2	67
		% within S3_StrategicAreas	0,0%	0,0%	6,8%	0,0%	3,2%	5,8%	16,7%	5,1%
	GD	Count	0	0	218	0	9	14	1	242
		% within S3_StrategicAreas	0,0%	0,0%	27,5%	0,0%	9,7%	10,2%	8,3%	18,5%
	GE	Count	15	23	30	3	2	4	0	77
		% within S3_StrategicAreas	18,3%	13,3%	3,8%	20,0%	2,2%	2,9%	0,0%	5,9%
	GJ	Count	14	10	56	0	3	4	0	87
		% within S3_StrategicAreas	17,1%	5,8%	7,1%	0,0%	3,2%	2,9%	0,0%	6,7%
	GM	Count	16	11	109	0	6	8	0	150
		% within S3_StrategicAreas	19,5%	6,4%	13,7%	0,0%	6,5%	5,8%	0,0%	11,5%
	GO	Count	2	4	93	0	0	1	0	100
		% within S3_StrategicAreas	2,4%	2,3%	11,7%	0,0%	0,0%	0,7%	0,0%	7,7%
	MD	Count	1	4	17	0	0	1	0	23
		% within S3_StrategicAreas	1,2%	2,3%	2,1%	0,0%	0,0%	0,7%	0,0%	1,8%
	MG	Count	8	12	2	3	2	0	0	27
		% within S3_StrategicAreas	9,8%	6,9%	0,3%	20,0%	2,2%	0,0%	0,0%	2,1%
	MH	Count	9	35	91	4	11	16	0	166
		% within S3_StrategicAreas	11,0%	20,2%	11,5%	26,7%	11,8%	11,7%	0,0%	12,7%
	MIP	Count	0	10	28	1	0	3	0	42
		% within S3_StrategicAreas	0,0%	5,8%	3,5%	6,7%	0,0%	2,2%	0,0%	3,2%
	ML	Count	0	0	7	0	0	1	0	8
		% within S3_StrategicAreas	0,0%	0,0%	0,9%	0,0%	0,0%	0,7%	0,0%	0,6%
	MM	Count	0	26	4	1	0	7	0	38
		% within S3_StrategicAreas	0,0%	15,0%	0,5%	6,7%	0,0%	5,1%	0,0%	2,9%
	MN	Count	0	13	17	0	0	4	0	34
		% within S3_StrategicAreas	0,0%	7,5%	2,1%	0,0%	0,0%	2,9%	0,0%	2,6%
	MR	Count	7	20	21	2	1	4	0	55
		% within S3_StrategicAreas	8,5%	11,6%	2,6%	13,3%	1,1%	2,9%	0,0%	4,2%

			S3_StrategicAreas							Total
			Bio & SM	Bio/Health	Energy	Energy & Bio	Energy & Bio & SM	Energy & SM	Smart Manufacturing	
	MS	Count	5	4	2	1	0	0	0	12
		% within S3_StrategicAreas	6,1%	2,3%	0,3%	6,7%	0,0%	0,0%	0,0%	0,9%
Total		Count	82	173	794	15	93	137	12	1306
		% within S3_StrategicAreas	100,0 %	100, 0%	100,0 %	100,0 %	100,0 %	100,0 %	100,0 %	100, 0%

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1404,224[a]	96	<,001
Likelihood Ratio	1010,267	96	<,001
N of Valid Cases	1306		

a. 66 cells (55,5%) have expected count less than 5. The minimum expected count is ,07.

5 Discussion

5.1 Research contributions

This study makes several important contributions to understanding how academic projects align with regional innovation strategies. First, it offers a comprehensive, data-driven overview of the distribution and evolution of bachelor's and master's theses over five years, highlighting the growing contribution of undergraduate education to regional innovation. Second, it provides empirical evidence linking academic programmes, geographic location, and S3 alignment, revealing patterns that can inform institutional planning and policy decisions. Third, it identifies key sectors (particularly Smart Manufacturing) as areas of strong student engagement, while also signalling underexplored domains that may require targeted institutional support. Finally, through robust statistical analysis, the study demonstrates how educational level, programme type, and regional context shape the thematic orientation of student projects, offering a framework for aligning academic output with strategic regional priorities.

Beyond this general contribution, the study generates insights for each of the triple helix actors: academia, industry, and government.

5.1.1 Contributions to academia

The findings show how structured student mobility serves as an effective mechanism for aligning academic work with regional innovation strategies. Analysis of more than 2,200 projects highlights the strong role of undergraduate education in driving innovation, particularly in Smart Manufacturing. The results underscore the importance of embedding regional priorities into curricula and project design, offering a reference model for institutions seeking to enhance their societal impact through education-driven university-industry collaboration. The study also enriches the entrepreneurial university literature by illustrating how dual education and final-year projects help bridge theoretical and practical knowledge.

5.1.2 Contributions to industry

For industry, the research shows the tangible value of collaborating with universities through thesis projects. The high alignment of BT with S3 sectors (especially Smart Manufacturing) demonstrates how companies can use academic collaborations to address real challenges and foster innovation. Student mobility also enhances employability and knowledge transfer, positioning

it as a strategic tool for talent acquisition and organisational learning. By engaging in dual education and hosting final-year projects, companies contribute to regional development while gaining access to new ideas, prototypes, and process improvements.

5.1.3 Contributions to government

From a policy standpoint, the findings provide actionable evidence on how student mobility and university-industry collaboration support S3. The consistent alignment of academic projects with regional priorities across provinces and years indicates that structured educational initiatives can act as powerful instruments of place-based innovation. The study highlights the need for policies that reduce geographic disparities and encourage engagement in underrepresented sectors. Governments can use these results to design incentives, funding schemes, and governance models that strengthen universities' roles as active agents in regional innovation ecosystems.

5.2 Limitations and future research directions

Given the growing number of undergraduate theses and their stronger alignment with RIS3 strategic areas, future research could investigate the factors driving this engagement. Exploring pedagogical approaches, institutional incentives, or curriculum structures that promote RIS3-related project development at the undergraduate level may offer insights for increasing participation at master's level.

Another promising avenue involves examining the geographic concentration of projects in Gipuzkoa. Although current data show no significant differences in RIS3 alignment across provinces, understanding local dynamics - such as industry presence, university partnerships, and student demographics - could inform strategies to achieve a more balanced distribution of projects across the Basque Country.

The strong representation of Smart Manufacturing suggests potential saturation or institutional bias. Future studies could assess whether this dominance reflects genuine innovation potential or limited diversification. Investigating underrepresented sectors such as Energy & Bio or Bio & Smart Manufacturing could help broaden the strategic focus and create new opportunities for interdisciplinary innovation.

Given the observed association between academic programmes and S3 sectors, further research could map competences and learning outcomes to strategic priorities, supporting the design of educational pathways more closely aligned with regional innovation needs and enhancing the impact of student projects.

Finally, methodological improvements should be considered. Limitations in the present analysis (such as low expected counts in some tests) indicate that future research would benefit from larger datasets, longitudinal tracking of project outcomes, and qualitative approaches that capture student and faculty perspectives on S3 alignment and project development.

5.3 Practical implications

The findings of this study offer valuable insights for academic institutions, policymakers, and regional innovation stakeholders. The strong alignment of undergraduate theses with S3 strategic areas indicates that bachelor's programmes are effectively incorporating regional innovation priorities into their curricula. This underscores the potential of undergraduate education as a driver of innovation and highlights the importance of strengthening support structures for final-year projects, such as mentorship, industry collaboration, and targeted funding.

The predominance of certain programmes (e.g., GM, MH, GD, GO) in project output and S3 alignment suggests these disciplines can serve as strategic anchors for institutional planning. Universities may use these patterns to identify best practices and extend them to programmes with lower engagement. Additionally, the high concentration of projects in Gipuzkoa points to possible regional disparities in academic-industry collaboration, encouraging policymakers to promote more balanced participation through incentives in underrepresented provinces such as Araba and Bizkaia.

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The strong focus on Smart Manufacturing carries notable implications for regional development. While this aligns with existing industrial strengths, it raises questions about possible underutilisation of other S3 sectors. Institutions and regional authorities could explore ways to build interest and capacity in emerging or less represented fields, fostering a more diversified innovation ecosystem.

Finally, the significant associations between thesis type, academic programme, and S3 sector indicate that more deliberate alignment between educational pathways and strategic priorities is both feasible and advantageous. This could inform curriculum design, career guidance, and industry partnerships. Nevertheless, limitations (such as reliance on quantitative data, lack of longitudinal tracking, and small sample sizes in some categories) highlight the need for more robust, mixed-methods research to support evidence-based decision-making.

6 Conclusions

This study provides evidence of the evolving role of universities in regional innovation ecosystems, particularly through education-driven collaboration. The analysis of 2,224 BT and MT theses from 2020 to 2024 reveals a clear upward trend in BT projects, which consistently outnumbered MTs, indicating a growing engagement of undergraduate students in final project activities. This trend aligns with the literature on entrepreneurial universities and the increasing relevance of work-integrated learning at the undergraduate level (Galan-Muros & Davey, 2017; Rampersad, 2015).

The strong alignment of BT projects with S3 priorities (especially in Smart Manufacturing) reinforces the strategic role of universities in supporting regional development through talent development and knowledge transfer (Aranguren & Magro, 2022; Burbridge & Morrison, 2021). Statistical analyses confirm that BTs are significantly more likely to be aligned with S3 sectors than MTs, with Smart Manufacturing and Bio/Health as dominant areas for BTs, while MTs are more prevalent in Energy-related sectors. This sectoral distribution reflects both institutional strengths and potential biases, as noted in critiques of S3 (Hassink & Gong, 2021).

Despite the geographic concentration of projects in Gipuzkoa (82.5%), alignment with S3 priorities remains consistent across provinces, suggesting effective regional integration and governance flexibility (Morgan et al., 2020). The prominence of programmes such as GM, MH, GD, and GO in project output further highlights the importance of curricular structure and institutional emphasis in shaping engagement with strategic innovation areas.

However, the underrepresentation of emerging sectors like Energy & Bio and Bio & Smart Manufacturing points to opportunities for diversification. The significant relationship between academic programmes and S3 sectors (although statistical interpretation is limited) suggests that aligning educational pathways with regional priorities could enhance the impact of university-industry collaboration. These findings underscore the need for adaptive policy mechanisms, continuous monitoring, and targeted support to ensure inclusive and balanced innovation across sectors and academic levels.

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European Scientific Journal for Dual Higher Education

Vol. 2, No. 1, (2026)
ISSN (online): 3052-7015

BIBLIOMETRIC ANALYSIS OF THE GLOBAL INTELLECTUAL STRUCTURE OF DUAL AND WORK-INTEGRATED HIGHER EDUCATION

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Keywords:
Work-integrated learning
Dual education
Bibliometric analysis
Universities
Employability

Article history:
Received: 14 January 2026
Revised: 27 April 2026
Accepted: 3 June 2026

Abstract
Dual and work-integrated learning (WIL) models are important for developing a skilled workforce. This article presents a large-scale bibliometric analysis of the dual and WIL research landscape. The objective of the study was to map the core concepts, thematic clusters, and temporal trends that define the global scholarly conversation. The study analysed 1,563 unique records published between 2006 and 2025, which were extracted from Scopus and Web of Science. A hybrid methodology combining custom Python-based scripts for data integration and network analysis with VOSviewer was used to examine keyword co-occurrence, centrality, and thematic clusters. The results reveal a field centred on students, curricula, and employability. Three dominant thematic clusters emerged: graduate employability and the student experience; engineering education and pedagogical frameworks; and professional development. A temporal analysis indicates a recent shift towards wellbeing and equity. This study provides a comprehensive, evidence-based map of this important research area.

1 Introduction

In response to persistent demands for a more agile and skilled workforce, educational institutions and governments worldwide are increasingly championing dual and work-integrated learning (WIL) models. These programmes, which formally integrate rigorous academic study with substantial, accredited work experience, represent an important component of the European Union's broader strategy to encourage innovation, address pressing socio-economic challenges, and build a resilient, competitive knowledge-based economy. While “dual study” denotes formalised, employer-integrated degree programmes that are prevalent primarily in German-speaking and Central European contexts, “work-integrated learning” is used here as the internationally adopted umbrella term for cooperative education, internships, and professional placements across diverse national systems. The two models are treated jointly in this study because they share a commitment to the structured integration of academic and professional learning. Initiatives such as the European Alliance for Apprenticeships (European Commission, n.d.) aim to align educational outcomes with the dynamic needs of industry, particularly supporting the critical green and digital transitions. To produce graduates who are not only theoretically knowledgeable but also demonstrably workforce-ready, these educational models focus on cultivating tangible employability skills (Jackson, 2015)

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and career management competencies (Jackson & Wilton, 2016) through deep immersion in professional contexts.

In light of this strategic importance, a growing body of research has emerged to understand and document these educational models. However, a comprehensive review of this literature reveals a distinct and prevailing research paradigm centred on descriptive national case studies. A significant volume of recent scholarship provides deep, context-rich examinations of individual countries, which, while intrinsically valuable, collectively highlight a critical gap in the field's self-understanding. The inaugural issue of the European Journal of Dual Higher Education illustrates this perfectly, featuring detailed analyses of established dual education frameworks in Austria (Dragan & Hochrinner, 2024) and Hungary (Sági & Fülöp, 2024), alongside explorations of the legal and practical pathways in nations such as Belgium (Dupouy & Bakni, 2024), Slovakia and Romania (Varga, 2024a; Varga, 2024b). This country-specific lens has also been applied rigorously to countries without a formal "dual" system, such as Finland and Sweden, whose strongly work-oriented models are analysed in their own right (Laukkanen et al., 2024; Viklund & Elgundi, 2024).

This rich mosaic of national studies provides an indispensable foundation for policymakers and practitioners. The success and proliferation of this context-rich research signal a new stage in the field's maturity, one that now calls for a complementary, macro-level synthesis. Such a synthesis would not replace detailed national accounts but would build on them, allowing us to ask broader questions that naturally arise from this collective body of work: what are the dominant theoretical frameworks that unify the field, which influential concepts transcend national borders, and which less visible collaborative networks connect researchers globally? The opportunity now exists to weave these distinct and vital conversations into a cohesive international discourse, revealing the intellectual architecture that underpins the entire field.

1.1 Foundational themes in work-integrated learning research

A review of the foundational literature on work-integrated learning (WIL) reveals a scholarly discourse focused on several interconnected themes: the development of graduate employability, the formation of professional identity, the critical importance of programme design and quality assurance, and the essential role of support systems. This body of research, anchored primarily in the Australian context (as evidenced by the corpus analysed in this study), provides the empirical and theoretical bedrock upon which a broader, global understanding of the field can be built.

The primary objective identified in the literature is the cultivation of graduate employability. Researchers consistently investigate how WIL programmes equip students with the necessary attributes to succeed in the modern workforce. This extends beyond simple job attainment to include the development of sophisticated career management competencies, enabling graduates to self-manage their professional pathways effectively in an era of increased employee mobility (Jackson & Wilton, 2016). The literature argues that WIL is instrumental in developing a wide range of tangible employability skills, though scholars also caution that the mere existence of a placement is insufficient; the quality of programme design is central to overcoming barriers and ensuring effective skill development (Jackson, 2015).

Moving beyond a purely skills-based definition of employability, a significant stream of research explores the role of WIL in the formation of pre-professional identity. This complex phenomenon, which encompasses a student's awareness of and connection with the values, standards, and behaviours of their chosen profession, is positioned as a critical but often underexplored aspect of graduate readiness (Jackson, 2017; Trede, 2012). Jackson's (2017) work demonstrates that work placements offer an invaluable platform for identity construction. Through observation, interaction with seasoned professionals, and structured reflection, students begin to build a professional self, a process that is as important to their future success as the application of disciplinary knowledge.

The effectiveness of these programmes depends on their structural integrity and the quality of their design. Smith (2012) addresses this directly by proposing a comprehensive framework for evaluating WIL curricula. This work highlights the key dimensions that underpin quality, including authenticity, integrated learning supports at both the university and the workplace, and the clear alignment of learning activities with outcomes. This focus on quality assurance and programme

architecture underscores a critical understanding in the field: the benefits of WIL are not automatic; rather, they result from deliberate and thoughtful pedagogical design.

Moreover, the literature illuminates the crucial role of human support systems in mediating the student experience. The academic advisor, for instance, is not a peripheral figure but plays a make-or-break role in student success (Wenham et al., 2020). This research identifies the substantial pastoral demands placed on advisors and identifies the need for robust institutional support, mentoring, and clear processes to help them manage diverse student issues, particularly concerning international students and those with mental health challenges. This focus on the support ecosystem is also echoed in the context of global pressures, where WIL is positioned as a key strategy for addressing skills shortages and preparing global citizens, with a particular focus on the unique needs and experiences of international students (Gamble et al., 2010).

1.2 Leveraging computational tools for bibliometric insight

The exponential growth in scholarly publications has rendered traditional manual review methods inadequate for capturing the full scope of research (Toaza & Esztergár-Kiss, 2024). Consequently, bibliometric analysis has become essential for mapping intellectual structures and identifying key conceptual clusters. While user-friendly software such as VOSviewer has made science mapping accessible, a powerful trend has emerged towards the use of programming languages, particularly Python and R, for more flexible, robust, and transparent analyses. This shift reflects the need to combine tools for specific analytical goals, as no single software is universally optimal (Moral-Muñoz et al., 2020).

Programmatic approaches offer several advantages. Python scripts can automate data searching, downloading, and cleaning, ensuring data quality and saving time (Toaza & Esztergár-Kiss, 2024). Furthermore, Python-based tools provide extensive and customisable analytical techniques, enabling advanced network analyses beyond basic metrics (Velasquez, 2023). Crucially, analysis via programming scripts enhances scientific rigour by ensuring transparency and reproducibility, a core principle for modern computational research (Butt et al., 2021). Building on this methodological trend, this study employs Python-based scripts in combination with VOSViewer to analyse the research landscape (Juhász, 2025). To address the fragmented nature of existing scholarship, this study proposes to construct a comprehensive mapping of the global intellectual structure of dual and work-integrated higher education.

1.3 Objectives and research questions

To provide a comprehensive, quantitative map of the scholarly conversation, this article presents a bibliometric analysis of global research output on dual and work-integrated higher education published between 2006 and 2025, drawn from the Web of Science (WoS) and Scopus databases. The analysis systematically charts the scholarly corpus, thereby moving beyond the limitations of siloed national contexts to reveal the field's underlying intellectual structure on a global scale.

To achieve this objective, the study is guided by the following research questions:

- RQ1: What are the core concepts and most influential themes that define the scholarly conversation on dual and work-integrated higher education?
- RQ2: What are the primary thematic clusters, and how do they structure the research landscape?
- RQ3: How has the field's thematic focus evolved over the last two decades?
- RQ4: What does this intellectual structure reveal about the current state and future direction of the field for both researchers and practitioners?

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2 Methodology

This study employs a quantitative bibliometric analysis to systematically map the intellectual structure, evolution, and key thematic clusters within the scholarly literature on dual studies and work-integrated learning. This research design was adopted to provide a comprehensive, macro-level overview of the field, moving beyond the descriptive national case study approach to uncover the underlying patterns in the global scholarly conversation.

2.1 Data collection and scoping

To ensure comprehensive coverage and mitigate the biases of any single source, the data collection strategy utilised two of the world's leading academic databases: the Web of Science Core Collection and Scopus. The search query was constructed to maximise both relevance and recall. The final query, applied to the topic fields covering titles, abstracts, and keywords, was: ("dual study" OR "work integrated learning" OR "cooperative education") AND ("university*" OR "academic*").

The data and structure consist of two conceptual components, which were gathered on 2 July 2025. The first captures the core educational model using its varied international terminologies, while the second component acts as a filter to ensure every result is situated firmly within a higher education context. To focus on contemporary developments, the timeframe was limited to an approximately 20-year period, from 2006 to 2025. Furthermore, to ensure the analysis was based on substantive, peer-reviewed research, the author restricted the included document types to Article, Proceeding Paper, and Review, and explicitly excluded all other document formats.

2.2 Data processing and analysis

The analysis employed a hybrid methodology, combining established visualisation software with custom programming scripts, aligning with contemporary scientometric best practices for specific analytical aims (Moral-Muñoz et al., 2020). A significant challenge in multi-source bibliometric research is record merging and de-duplication; this was addressed by creating custom Python scripts. The script parsed the raw data and implemented a multi-tiered matching algorithm, utilising DOIs and title/author combinations to create a clean, consolidated database.

Following integration, the scripts facilitated critical data cleaning by standardising keyword terms (e.g., "work integrated learning" merger) and excluding generic, non-thematic keywords to ensure conceptual consistency and prevent distortion of network visualisations. The hybrid analytical workflow leveraged VOSviewer for exploratory visualisation and exported data to custom Python scripts for detailed quantitative analysis in a Jupyter Notebook file, using the Google Colab Research platform; the complete analytical scripts are openly deposited on Zenodo (Juhász, 2025), ensuring full reproducibility. Using the Pandas, NetworkX, Matplotlib libraries, and VOSviewer, the scripts enabled a series of in-depth analyses, including the construction of a keyword co-occurrence network to map the field's intellectual structure, the employment of community detection algorithms to objectively identify distinct thematic clusters, the examination of keyword usage evolution over 20 years to identify emerging and fading trends, and the calculation of four distinct centrality measures to determine the structural importance of key concepts derived from keyword analysis.

It should be noted that the visual network maps are the result of deliberate data curation to enhance analytical clarity. To prevent the visualisations from being dominated by a few overly broad terms, the core search-query keywords were excluded from the final map generation and centrality analysis. Highly frequent terms like "work-integrated learning", "cooperative education", and "higher education" were intentionally deselected. Including these "header terms" would have created a single, dense super-node at the centre of the network, obscuring the more subtle and meaningful relationships between specific thematic concepts such as employability, curriculum design, and nursing education. This exclusion is not a limitation of the data itself, but a standard and necessary step in science mapping to produce a more interpretable and meaningful intellectual map.

By contrast, terms such as “students” and “education” were deliberately retained, as these represent researcher-assigned index descriptors rather than search-query artefacts; their high centrality therefore constitutes a substantive empirical finding about the field's orientation.

3 Results and Discussion

The bibliometric analysis of the consolidated dataset reveals a complex and highly structured research landscape. The findings, presented through network visualisations and quantitative metrics, illuminate the field's core intellectual architecture, its primary thematic pillars, and its dynamic evolution over the last two decades.

3.1 Data corpus overview and processing results

The multi-stage data collection and cleaning process yielded a robust final corpus for analysis. As illustrated in the Final Processing Overview (Figure 1), the initial search retrieved 1,202 documents from the Scopus database and 1,090 from the Web of Science, resulting in a combined total of 2,292 records.

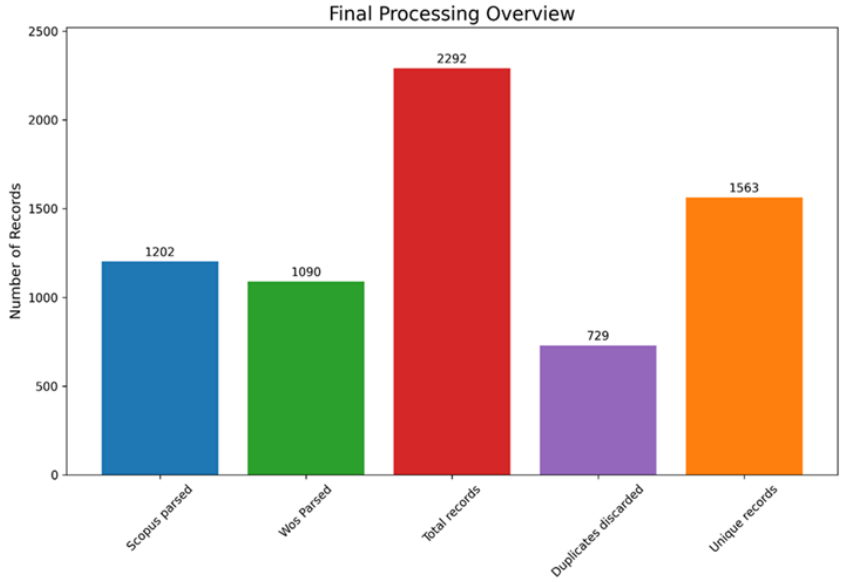

Figure 1. Final Processing Overview of Records, author's own edit

The subsequent de-duplication process, performed by the author's custom script, identified and discarded 729 duplicate entries. This procedure resulted in a final corpus of 1,563 unique scholarly records, which form the basis for all subsequent analysis. The decision to use both databases was supported by an analysis of source contributions to the final unique dataset, as shown in Figure 2.

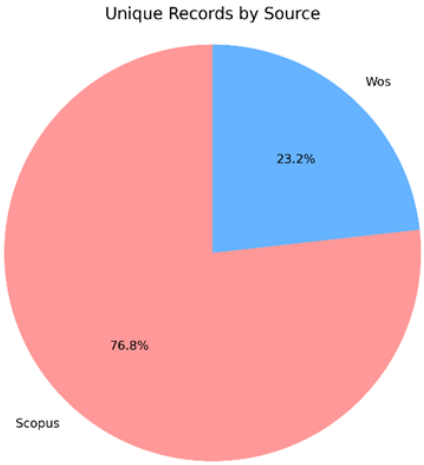

Figure 2. Unique Records by Source, author's own edit

The second figure demonstrates that Scopus was the source for 76.8% of the unique records, while Web of Science contributed the remaining 23.2%. This disparity underscores the necessity of a multi-source approach, as relying on a single database would have resulted in overlooking approximately one quarter of the relevant scholarly literature.

The temporal distribution of these 1,563 unique publications (Figure 3) reveals a clear and sustained growth in academic interest over the last two decades.

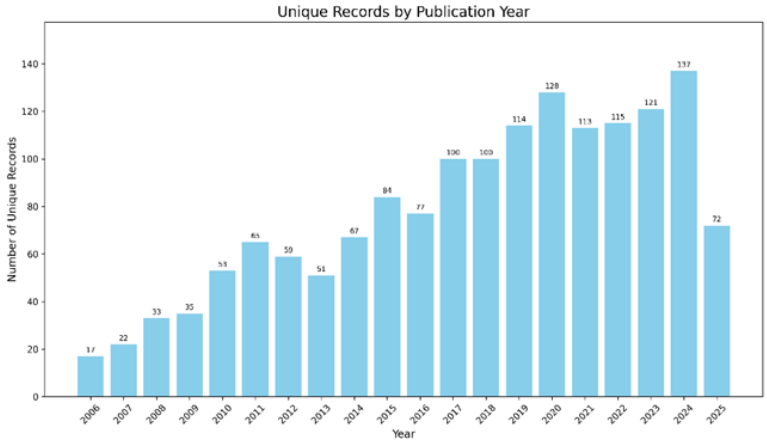

Figure 3. Unique Records by Publication Year, author's own edit

From a modest start of just 17 publications in 2006, the annual output shows a consistent upward trajectory, peaking at 137 publications in 2024. This increase in annual research output quantitatively indicates the expanding significance of, and growing scholarly attention to, dual and work-integrated higher education. It is important to note that the data for 2025 reflects a partial count for the year at the time of data collection.

To examine the geographic scope of the corpus, an analysis of author affiliations by region (Figure 4) reveals that, while the dataset draws from six major world regions, scholarly output is markedly uneven in its distribution.

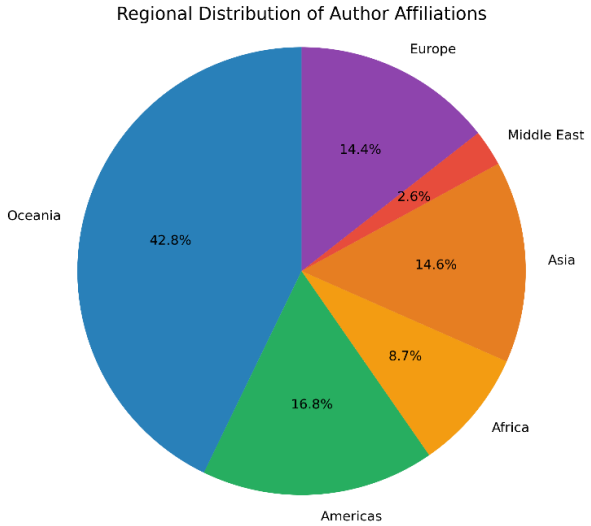

Figure 4. Regional Distribution of Author Affiliation, author's own edit

As illustrated in Figure 4, Oceania accounts for the largest regional share at 42.8%, a contribution driven almost entirely by Australian institutions, reflecting the country's disproportionate prominence in work-integrated learning research relative to its higher education system size. The Americas (16.8%), Asia (14.6%), and Europe (14.4%) follow with broadly comparable shares,

suggesting meaningful but secondary engagement across these regions. African institutions contribute 8.7% of affiliations, with South Africa as the dominant national contributor within this group. The Middle East accounts for the remaining 2.6%. Within Europe, output is distributed across numerous national contexts, with no single country holding a dominant share. This regional pattern is consistent with the established bibliometric centrality of Australia in the field and is discussed further in relation to the thematic findings below.

3.2 The core architecture of the field

The keyword co-occurrence network (Figure 5) demonstrates a field organised around a dense conceptual core with several distinct and specialised peripheral areas.

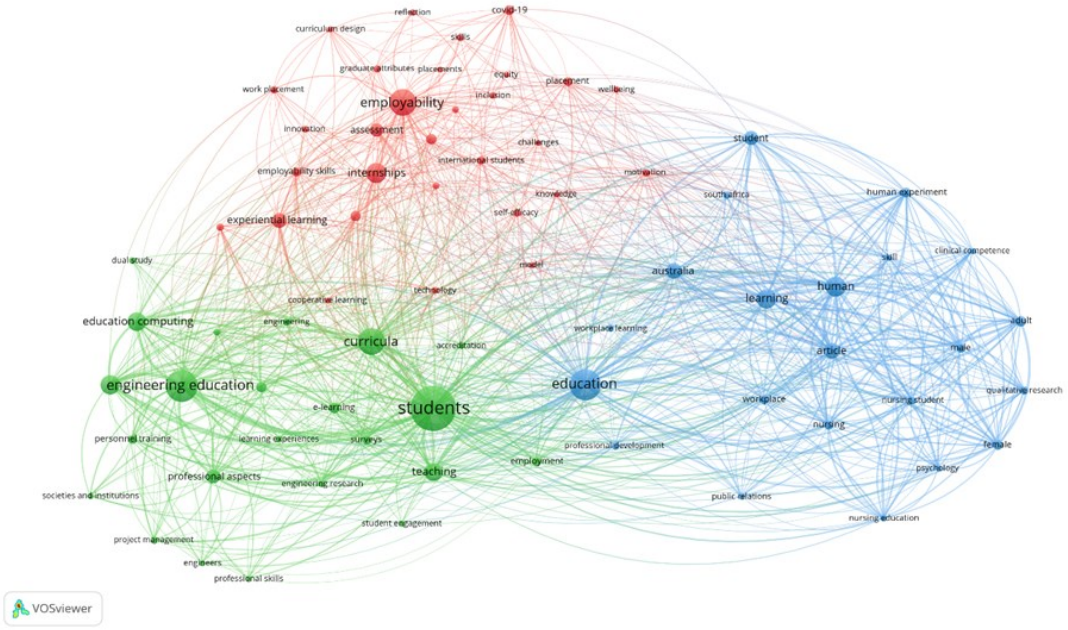

Figure 5. Keyword Co-Occurrence Network, VOSViewer

A quantitative examination of keyword centrality underscores this structure. Raw keyword occurrences (Table 1) confirm the visual centrality of key terms.

Table 1. Keyword Occurrences

Keyword	*Occurrences*
students	289
engineering education	171
education	167
curricula	135
employability	134
human	90
internships	87
apprentices	85
learning	85
education computing	77

The keyword students is, by a significant margin, the most frequently occurring thematic concept (289 occurrences), followed by engineering education (171) and education (167). This top tier is completed by concepts central to educational design and outcomes: curricula (135) and employability (134), affirming a strong focus on learners, specific vocational contexts, and practical goals.

This raw frequency translates directly into network influence, as measured by Total Link Strength (Table 2).

Table 2. Keyword Total Link Strength

Keyword	*Total Link Strength*
students	1128
education	785
human	659
engineering education	584
learning	577
article	493
curricula	489
teaching	355
adult	300
female	292

Students again dominate with a link strength of 1128, while broad concepts like education (785) and human (659) demonstrate their role as highly integrative themes by connecting to a wide and diverse array of other topics across the entire network.

The network's architecture is further illuminated by the various centrality metrics (Table 3), each telling a part of the structural story.

Table 3. Keyword Centrality Analyses

Keyword	*Degree Centrality*	*Closeness Centrality*	*Betweenness Centrality*	*Eigenvector Centrality*
students	0.9595	0.9610	0.0502	0.4481
curricula	0.9324	0.9367	0.0441	0.2301
education	0.9189	0.9250	0.0410	0.3548
teaching	0.8243	0.8506	0.0313	0.1780
learning	0.7703	0.8132	0.0219	0.2599
employability	0.7432	0.7957	0.0294	n/a
australia	0.7162	0.7789	0.0193	n/a
engineering education	0.6757	0.7551	0.0191	0.2864
article	0.6486	0.7400	n/a	0.2350
human	0.6351	0.7327	n/a	0.2991

As shown in the table above, the high Degree Centrality of students (0.9595), curricula (0.9324), and education (0.9189) indicates a field heavily centred on the core aspects of educational practice and design. The presence of teaching, learning, and employability among the top-ranked terms reinforces this focus on student outcomes and pedagogical effectiveness, while the inclusion

of Australia and engineering education points to a geographically anchored and discipline-specific concentration of research.

This finding is strongly corroborated by the Closeness Centrality results. The high scores for the same core keywords suggest a well-connected research network focused on how educational practices prepare students for future careers. The near-identical ranking of the top keywords across both Degree and Closeness Centrality confirms the presence of a highly cohesive and efficient intellectual core.

The Betweenness Centrality scores offer a more nuanced perspective. While the top-ranking keywords are consistent with other metrics, their actual centrality values are relatively low, with the highest score only 0.0502 for students. This important finding suggests that the research network is highly integrated and does not rely on a few critical nodes to bridge structural holes between topics. The thematic clusters are already well-connected, reflecting a field characterised by interconnected research on student-centred learning, curriculum design, and professional preparation.

Finally, Eigenvector centrality measures influence based on the importance of a node's connections. The dominance of students (0.4481) and education (0.3548) suggests a field heavily focused on pedagogical practices and the training of future professionals. The high rank of human (0.2991) alongside engineering education suggests a significant emphasis on the human aspects of education in technical disciplines, potentially encompassing areas such as human-centred design. These strong connections among influential keywords indicate the existence of well-established research clusters focused on enhancing learning experiences in engineering and education.

3.3 Thematic pillars with temporal analysis

Beyond the individual influence of key concepts, the network is organised into three distinct and highly coherent thematic regions. These keyword clusters, shown in Figure 5 and Table 4, were identified through algorithmic partitioning of the network, revealing the primary sub-fields where dual and work-integrated learning are investigated. Each cluster represents a unique community of practice within the broader scholarly conversation.

Table 4. Keyword Cluster Analysis

Cluster ID	*Coherence*	*Top Keywords*
Cluster 2 (green in Figure 4)	7,6684	societies and institutions, engineering education, engineering research, learning experiences, professional aspects...
Cluster 3 (blue in Figure 4)	10,6589	professional development, qualitative research, clinical competence, workplace learning, nursing education...
Cluster 1 (red in Figure 4)	1,9543	graduate employability, international students, experiential learning, professional identity, cooperative learning...

Cluster ID 1, with a coherence score of 1.9543, is intensely focused on the complex aspects of graduate employability, particularly in relation to experiential learning, internships, and the unique needs of international students. This cluster is the most diverse of the three, suggesting it acts as an intellectual hub that integrates a wide range of concepts related to the student journey from university to the workforce. It explores how approaches such as cooperative learning can support the development of a strong professional identity and ultimately improve employability outcomes, with top keywords including graduate employability, international students, experiential learning, professional identity, and cooperative learning.

Cluster ID 2 is dominated by a highly influential node and serves as the intellectual home for research on the practical design and implementation of integrated learning models. With a strong coherence score of 7.6684, this theme is well-defined and interconnected. Its core keywords, such as curricula, learning experiences, and professional aspects, highlight a central focus on preparing

future engineers by bridging the gap between academic learning and professional practice. The inclusion of societies and institutions suggests that this research also considers the broader societal context and impact of engineering education.

Finally, Cluster ID 3's thematic pillar is the most cohesive in the entire network with notably high coherence score of 10.6589. This indicates a mature, focused, and tightly interconnected area of research. The cluster is clearly delineated around the intersection of professional development and clinical competence within the specific context of nursing education and workplace learning. The prominence of qualitative research within this cluster suggests a methodological preference for in-depth exploration of the lived experiences of acquiring and demonstrating practical skills, with top keywords including professional development, qualitative research, clinical competence, workplace learning, and nursing education.

Crucially, the network overlay's temporal analysis visualisation (Figure 6) further reveals that this intellectual landscape is not static but has evolved significantly over time.

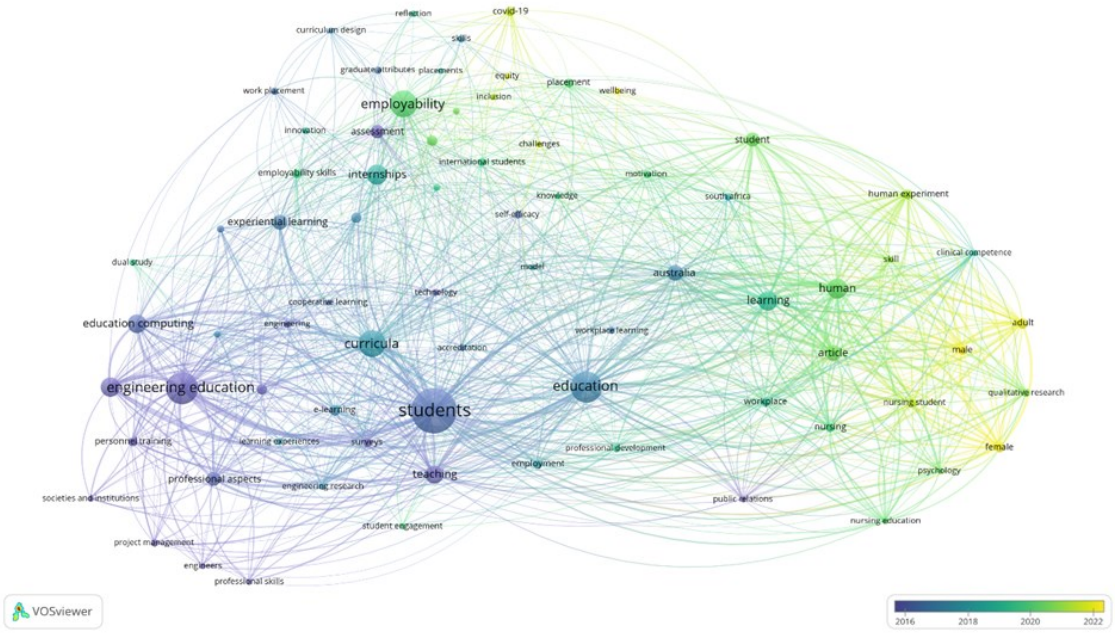

Figure 6. Temporal Overlay of Keyword Co-Occurrence Network, VOSViewer

The overlay map illustrates this dynamic by colour-coding keywords based on their average publication year, with older terms in blue and more recent terms in yellow. Foundational concepts in the field, such as students, education, and teaching, appear in darker blue, indicating their established presence since the earlier years of the analysis period. The most recent research fronts, however, are concentrated in bright yellow nodes that have emerged prominently since 2021. This recent shift is most pronounced in Cluster 1, where a suite of new concepts has appeared.

Table 5. Keywords Average Publication Year

Keywords	*Avg. Pub. Year*
wellbeing	2022,7222
male	2022,0345
female	2021,8667
adult	2021,6667
equity	2021,6667
covid-19	2021,3226
challenges	2021,3125
nursing student	2021,2381
inclusion	2021,1176
human experiment	2020,9667

Here, the most recent keywords across the entire network appear, including wellbeing (2022.7), equity (2021.7), and COVID-19 (2021.3). This indicates a distinct evolution in the conversation around employability, incorporating a more holistic and socially aware perspective.

This indicates that the research conversation in this domain is evolving significantly, expanding from a traditional focus on skills and preparedness to a more holistic understanding of the graduate experience, one that now incorporates broader concerns for student wellbeing, equity, and the effects of external global factors.

Similarly, Cluster 3 demonstrates a recent evolution, with the keywords male (2022.0) and female (2021.9) emerging as contemporary topics. This points to a growing scholarly interest in understanding and addressing gender-specific factors within nursing education and professional development. The term human experiment (2021.0) also appears as a recent node, suggesting a rising focus on simulation-based training, evidence-based pedagogical interventions, and the ethical considerations surrounding clinical education, particularly in the post-pandemic era. These temporal shifts indicate the field’s responsiveness to contemporary societal issues and its continuous adaptation to new challenges and research methodologies.

3.4 Discussion

The volume of literature confirms that dual and work-integrated higher education is a specialised, nascent, and growing area of academic inquiry, rather than a long-established discipline. This analysis thus provides a comprehensive map of this focused scholarly domain.

In relation to RQ1, the scholarly conversation is defined by the strong centrality of students, curricula, and employability, forming the intellectual bedrock of the field with an overarching focus on the learner's journey, pedagogical design, and practical outcomes. This focus is anchored in key vocational domains (engineering and nursing) where theory-practice integration is both methodologically expected and professionally mandated. Influential themes like engineering education and human factors highlight the field's vocational orientation and its concern for the human element in technically demanding disciplines. Australia also emerges as a highly central node across all four centrality metrics, indicating its substantial influence in shaping the foundational literature of the field. The dominance of Australia as a central node reflects the country's early institutionalisation of WIL frameworks and its sustained contribution to the empirical and theoretical foundations of this research area.

In response to RQ2, the network is structured into three primary thematic pillars, each representing a distinct community of practice. Cluster 3 (nursing education) and Cluster 2 (engineering education) represent mature, highly focused research areas with strong coherence scores of 10.66 and 7.67 respectively, emphasising professional development and the integration of technical knowledge with workplace practice. Notably, "dual study" is firmly associated with the engineering cluster in the literature, suggesting that the formalised, employer-integrated model has

found its primary scholarly articulation within technical education discourse. In contrast, Cluster 1, centred on graduate employability and international students, is more diverse with a coherence score of 1.95, serving as a dynamic hub that synthesises concepts from experiential learning, professional identity, and cooperative education to prepare graduates for the job market across multiple disciplines.

In relation to RQ3, the temporal analysis indicates a significant and accelerating evolution in the field's focus over two decades. The most compelling finding is the clear temporal shift evidenced by the recent emergence of keywords such as "wellbeing" (avg. publication year 2022.7), "equity" (2021.7), "male" and "female" (2022.0 and 2021.9), and "COVID-19" (2021.3). This suggests a substantial shift, likely accelerated by the pandemic, indicating a move beyond purely economic or skills-based justifications toward a more humanistic and socially responsible model that actively addresses gender disparity, student mental health, and inclusive educational practices. The appearance of "human experiment" further signals rising interest in the ethical dimensions of educational research and complex adult learning, particularly through simulation-based and technologically mediated approaches.

Finally, in relation to RQ4, this intellectual map reveals both a mature, vocationally focused core and clear frontiers for future inquiry. The field emphasises practical outcomes, particularly in engineering and nursing, yet its emerging research fronts point in a more expansive direction. First, the field should move beyond general employability to examine its contemporary components and investigate how dual study curricula can integrate training for green and digital transitions. Second, the recent shift towards wellbeing and equity requires empirical testing of specific interventions that promote mental health and inclusive learning environments within WIL contexts. Third, interdisciplinary inquiry is needed to explore how structured pedagogical models from engineering could enhance training in other fields, and how the patient-centred care ethos of nursing education could enrich technical workforce formation. Finally, the emergence of the keyword "human experiment" as a recent node points to an emerging discussion on ethics and technology, requiring focused studies on the responsibilities of universities and industry partners in ensuring student safety, data privacy, and psychological wellbeing within technologically mediated learning environments.

Beyond future research directions, these findings carry direct implications for curriculum design and policy. Programme designers should treat the emerging centrality of wellbeing and equity not as peripheral concerns but as core design criteria to be addressed in the structural design of WIL programmes, alongside the established emphases on employability skills and disciplinary competence. At the policy level, the identified gap around green and digital transition competencies represents a strategic priority: supranational frameworks such as the European Alliance for Apprenticeships are well-positioned to incentivise employer partnerships that explicitly embed these competencies within dual and work-integrated degree structures, translating bibliometric signals into actionable curricular priorities.

Viewed against the national studies discussed in the introduction, these global cluster patterns have both confirmatory and complementary significance. The strong coherence of the engineering cluster aligns with the structured, employer-partnered dual models documented in Central European contexts, where the formalised integration of academic study and professional practice is a defining institutional feature (Dragan & Hochrinner, 2024; Sági & Fülöp, 2024). Conversely, the diversity and breadth of Cluster 1 mirrors the broader, less institutionally prescribed WIL traditions of Scandinavian and Anglo-Saxon systems, where work-oriented education takes multiple forms without a singular structural mandate (Laukkanen et al., 2024; Viklund & Elgundi, 2024). This correspondence between the macro-level bibliometric structure and micro-level national accounts suggests that the global intellectual architecture of the field is not arbitrary but reflects genuinely distinct educational and institutional traditions.

4 Conclusions

This study mapped the intellectual structure of the global research landscape on dual and work-integrated higher education through a comprehensive bibliometric analysis of 1,563 unique

records drawn from Scopus and Web of Science. Taken together, the findings establish a coherent and evolving field anchored in student-centred, vocationally oriented scholarship across engineering and nursing education, with a clear recent trajectory towards broader humanistic and socially conscious concerns, most visibly in the rising centrality of wellbeing, equity, and inclusion.

This bibliometric map provides both researchers and practitioners with an evidence-based orientation to a field that is simultaneously mature in its vocational core and dynamic in relation to its emerging frontiers. It confirms the global intellectual coherence of what national case studies tend to examine in isolation, demonstrating that European, Anglo-Saxon, and Australasian traditions are not isolated silos but interconnected threads within a shared scholarly architecture. Future work should build on this structural overview through targeted qualitative inquiry and interventional research, particularly in the areas of student wellbeing, equity, and competency development for green and digital transitions.

4.1 Limitations

While this bibliometric analysis provides a broad macro-level overview, its conclusions should be interpreted in light of several methodological limitations. Although the dataset is sourced globally, the study's theoretical framework heavily draws on European educational policy discussions. Therefore, researchers applying these findings in non-European contexts should consider this conceptual bias. First, because the analysis is based on metadata, it offers a high-level structural perspective but does not capture the detailed richness or argumentative subtleties of full texts. Second, relying on Scopus and Web of Science excludes publications not indexed there, such as some books, regional journals, or highly specialised articles. Nevertheless, the transparent methodology adheres to established scientometric standards, offering a reliable, data-driven overview of the key themes and intellectual structures shaping the international discourse on dual and work-integrated higher education.

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EU4Dual

ISSN: 3052-7015

This journal is part of
EU4DUAL