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A jump start to open innovation: A multidimensional competence profile in an international setting

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ABSTRACT

Objective: This study investigates open innovation (OI) competence development through a dynamic capabilities lens, offering a systematic understanding of how OI competencies are distributed across higher education contexts in mature and post-transition economies.

Research Design & Methods: We conceptualised and measured OI competencies among 397 engineering students from three European countries – Denmark, Latvia, and Poland – representing both mature and post-transition economies. Using multigroup latent profile analysis (LPA), we identified empirically determined patterns of competence distribution. This methodological approach enables robust cross-cultural comparison while accounting for national contextual variations.

Findings: Results revealed three distinct OI competence profiles with significant cross-national variations. Latvian students demonstrated higher entrepreneurship and risk-taking competencies, Danish students excelled in digital skills, while Polish students showed moderate levels across dimensions. Gender analyses uncovered unexpected patterns: women students were significantly more represented in high OI profiles in Poland and Latvia, while men dominated high profiles in Denmark.

Implications & Recommendations: For higher education institutions, our findings emphasise the need for contextually sensitive OI learning environments. For practitioners, our OI Competence Profile provides a framework for recruitment and team development across different national contexts.

Contribution & Value Added: This study advances OI theory by validating a comprehensive competence profile that functions as a first-order dynamic capability. Our multi-country, gender-inclusive approach reveals how educational, cultural, and economic factors shape innovation competency development across different national contexts.

Article type: research article

Keywords: open innovation; competence; multigroup latent profile analysis; Higher Education Institutions; post-transition economies

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INTRODUCTION

The paradigm of open innovation (OI) has fundamentally transformed how organisations develop and commercialise innovative products, services, and processes. Chesbrough's (2003) foundational framework highlights how organisations could benefit from both 'outside-in' knowledge flows, where external knowledge is brought into the organisation, and 'inside-out' flows, where internal ideas are commercialised through external channels. Numerous studies have investigated the advantages, limitations, and challenges associated with both inbound and outbound open innovation practices (Carmona-Lavado *et al.*, 2021). To fully capitalise on external knowledge flows, organisations must cultivate distinct open innovation competencies at the employee level (Mahdad *et al.*, 2020; Podmetina *et al.*, 2018).

We developed an OI Competence Profile that integrates six essential competencies and examined the critical learning contexts that support their development in individuals (El Maalouf *et al.*, 2022). Previous OI literature has conceptualised innovation skills in a broad and often ambiguous manner (Bogers *et al.*, 2018), with varying definitions of competencies related to successful open innovation implementation (Teece, 2020). This conceptual uncertainty has resulted in defining OI competence through separate, isolated competencies such as creativity, communication skills, and problem-solving (Podmetina *et al.*, 2018). From a practical perspective, organisations face significant challenges in identifying the optimal configuration of competencies required for recruiting employees best suited for OI implementation.

Relatively few studies have explored the learning contexts – particularly higher education – that foster OI competencies, which subsequently support diverse portfolios of OI activities in industrial settings. Limited research exists regarding the significance of higher education institutions (HEIs) in OI development and how university education could systematically cultivate these competencies (Carayannis & Morawska-Jancelewicz, 2022; Ovbiagbonhia *et al.*, 2023). Furthermore, while OI is gaining importance in post-transition economies, empirical investigations in these contexts remain scarce. Existing studies suggest that OI practices might be less developed in post-transition economies compared to mature economies, with companies in transitional contexts relying more heavily on internal R&D and less on external partnerships for innovation (McPhillips, 2020; Stojčić, 2021).

Post-transition economies face unique innovation challenges, including insufficient infrastructure, limited access to qualified personnel, and underdeveloped regulatory frameworks to support collaborative innovation (Stojčić, 2021). Despite these constraints, OI presents significant opportunities for economic development in these regions. Developing robust OI competencies could enable companies in post-transition economies to access new technologies, markets, and resources that enhance their global competitiveness (Akhmadi & Tsakalerou, 2022).

Based on these research gaps, our study contributes to the literature by exploring OI competencies exhibited by students in higher education institutions that can later be leveraged in organisational contexts. Grounded in dynamic capabilities theory (Teece, 2020; Bogers *et al.*, 2019), we analyse the role of HEIs in facilitating OI capability development. Dynamic capabilities refer to an organisation's capacity to assimilate, develop, and revise both indigenous and exogenous competencies in response to rapidly changing environments (Teece, 2020). Our research objective is to explore students' OI competencies as potential dynamic capabilities that will ultimately support organisations in achieving competitive advantages through open innovation strategies.

We gathered data from three European countries – Denmark, Poland, and Latvia – to enhance understanding of OI in both mature and post-transition economies. This cross-cultural comparative approach builds on work by Zhang *et al.* (2023), which suggests that while specific OI outcomes may vary across countries, fundamental competencies that drive innovation remain consistent across diverse contexts. The unique cultural and institutional characteristics of each country provide valuable insights into the development of OI competencies within different educational frameworks.

Most studies defining various OI competencies have not empirically measured competence levels in individuals. We addressed this gap by examining both the prevalence of different OI competencies and measuring their levels among university students before they enter organisational contexts. This timing is methodologically significant, as subsequent organisational factors – such as firm-specific OI training and innovation climate – may influence individual OI competence levels (Burcharth & Fosfuri, 2015). Therefore, we focused on students in their final years before graduation to establish baseline competence levels before organisational socialisation.

This article illuminates critical factors, namely university education efforts, national context, and gender, that significantly influence the development of OI competence profiles. Previous research on OI competence has typically conceptualised it in general terms (Bogers *et al.*, 2018) or through qualitative case studies (Chatenier *et al.*, 2010), often examining single countries without consideration of gender dimensions. Our multi-country, gender-inclusive approach addresses these limitations and contributes to a more comprehensive understanding of OI competence development (Krieger *et al*., 2022; Zuraik *et al.*, 2020).

To develop our competence profile, we integrated the European Skills, Competences, Qualifications, and Occupations (ESCO) framework with a comprehensive analysis of OI competence literature.

We specifically focused on competencies demanded by companies implementing OI activities (McPhillips *et al.*, 2022). Drawing from primary interviews with OI team managers and preceding empirical studies, we identified, selected, and aggregated key competencies into an OI Competence Profile representing antecedents to successful OI performance (El Maalouf *et al.*, 2022).

Based on OI competence profiles of university students across three European countries, our findings support the significant role of HEIs in developing OI competence. The focus on higher education represents a substantial contribution to OI literature and highlights the necessity of creating effective OI learning contexts during tertiary education (Leskinen *et al.*, 2023). By developing and acquiring OI competencies, future employees can more productively assimilate and redistribute knowledge relevant to innovation processes.

This article is structured as follows. We begin with this introduction and continue with a comprehensive literature review on the development of the OI Competence Profile and the role of HEIs in cultivating OI competence. We then present our methodological framework and operationalisation, followed by empirical findings. The final section offers conclusions, theoretical and practical contributions, limitations, and future research directions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Open innovation (OI) represents a paradigm shift in how organisations develop and commercialise new products, services, and processes. Rather than relying exclusively on internal R&D capabilities, OI involves engaging with external partners and leveraging diverse knowledge sources, including research institutions, customers, suppliers, and broader innovation ecosystems (Bogers *et al.*, 2019; Chesbrough, 2003). The fundamental objective of OI is to accelerate innovation processes, enhance creativity, and increase effectiveness by harnessing the collective intelligence of a diverse array of stakeholders (Bertello *et al.*, 2022). In the high-tech sector, firms embracing OI approaches demonstrate superior innovation outcomes, including higher patent output, compared to those relying solely on internal R&D capabilities (Holgersson & Granstrand, 2022).

OI activities encompass processes of actively seeking, assimilating, and integrating external knowledge, ideas, and resources into an organisation's innovation framework. These activities include scientific collaborations, crowdsourcing, co-creation initiatives, OI competitions, open sourcing, and corporate venturing (Rauter *et al.*, 2019). While numerous studies have identified isolated determinants of effective OI implementation, such as absorptive capacity, strategic orientation, and partner composition (Greco *et al.*, 2017), research highlights that complementary resources like human capital, partnership-building abilities, and multi-partner learning capabilities are critical for successful OI outcomes (Carmona-Lavado, 2021).

Organisations increasingly depend on arrays of complementary competencies to support OI teams and effectively manage employee-centred challenges in OI implementation (Bogers *et al.*, 2018). Individual competencies encompass skills, knowledge, and personal attributes necessary for successful engagement in OI activities (McPhillips *et al.*, 2022).

By aggregating clusters of key competencies essential for individuals involved in OI processes, we have identified the most frequently referenced competencies in the literature: creativity, communication, networking, entrepreneurship, open-minded thinking, risk-taking attitude, and self-efficacy in digital skills. Creativity, *i.e.*, the ability to generate novel ideas, is crucial for OI as it enables individuals to contribute innovative solutions (Engelsberger *et al.*, 2022; Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018). Effective communication competencies are essential for OI success, as individuals must convey ideas and information to both external partners and internal stakeholders. Networking capabilities, *i.e.*, the ability to build and sustain relationships with external partners, allow individuals to access new ideas and resources beyond organisational boundaries (Behnam *et al.*, 2018; Podmetina *et al.*, 2018; Du Chatenier *et al.*, 2010). Entrepreneurship encompasses the competencies required for managing innovation processes and implementing ideas. Studies demonstrate that individuals with entrepreneurial mindsets more readily identify and pursue OI opportunities and successfully implement OI initiatives (Bogers *et al.*, 2018; Du Chatenier *et al.*, 2010). Beyond these 'classic' OI competencies, recent em-

pirical studies underscore the importance of open-minded thinking (Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018). Since OI often involves collaborating with partners from diverse cultural backgrounds, cultural awareness and adaptability to different norms constitute important competencies for individuals in OI contexts (Podmetina *et al.*, 2018). Another key capability emphasised in the literature is a risk-taking attitude and adaptability to uncertain situations. Individuals engaged in OI must demonstrate resilience and flexibility in responding to changing conditions and potential failure (Engelsberger *et al.*, 2022). Emotional responses to tensions significantly influence OI practice effectiveness (Stefan *et al.*, 2022). Finally, self-efficacy in digital skills represents an emerging essential competence for individuals involved in OI, as proficiency with digital technologies becomes increasingly critical for innovation in contemporary business environments (Marion & Fixson, 2020; Enkel *et al.*, 2020). Digital technologies substantially impact the composition and performance of OI teams (Bogers *et al.*, 2018), and self-efficacy in digital skills correlates positively with individual innovation performance and innovative behaviour (Urbinati *et al.*, 2020). Table 1 explains how each competency cluster corresponds to specific OI activities, based on the ESCO framework.

Table 1. OI competence clusters and related OI activities

Competence type	Relevance for OI activity (based on the ESCO framework)
Creativity (Engelsberger *et al.*, 2022; Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018)	Creating new ideas, integrating existing ones, and carrying out activities in innovative and creative ways.
Communication and Networking (Podmetina *et al.*, 2018; Behnam *et al.*, 2018; Du Chatenier *et al.*, 2010)	Communicating, knowledge sharing, cooperating, mutual learning, integrating information from different sources, and using external knowledge for problem-solving.
Entrepreneurship (Du Chatenier *et al.*, 2010; Bogers *et al.*, 2018; Hafkesbrink & Schroll, 2014)	Organising tasks, leading other people, taking responsibility, anticipating future problems, actively managing them, spotting opportunities, and implementing plans.
Open-minded thinking (Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018)	Being flexible in thinking; the ability to work in cross-functional, cross-disciplinary, and cross-cultural teams.
Risk-taking attitude (Engelsberger *et al.*, 2022; Stefan *et al.*, 2022)	The ability to cope with uncertainty and ambiguity; the ability to accept risk and failure.
Self-efficacy in digital skills (Marion & Fixson,2020; Enkel *et al.*, 2020; Bogers *et al.*, 2018; Urbinati *et al.*, 2020; Tomczak *et al.*, 2023)	Using digital tools needed by the organisation; communicating and sharing resources online; data proficiency and data security abilities; interacting with different interfaces; understanding industrial application of digital technologies.

Source: own elaboration based on literature review, pilot study, and ESCO framework.

OI literature suggests that for organisations to effectively absorb knowledge through OI partnerships, they must develop specific competencies (Bogers *et al.*, 2018). Human capital theory (Becker, 1964; Deming, 2022) distinguishes between organisation-specific and general human capital. While organisation-specific human capital relates to particular positions or organisational contexts, general human capital encompasses transversal competencies applicable across different settings. Higher education represents a primary source of general human capital in innovative organisations and constitutes a significant learning environment supporting the development of OI competencies.

A substantial distribution of OI competencies through higher education exposure enhances individuals' awareness of and readiness for OI practice. Moreover, tertiary education may help overcome not-invented-here and not-shared-here syndromes (Marzi *et al.*, 2023). Education focused on OI competencies could reduce individuals' tension and uncertainty regarding inter-organisational partnerships (El Maalouf *et al.*, 2022), and well-designed curricula may better prepare students for work in external collaborative contexts. Moreover, education in OI cooperation competencies could minimise students' prejudgments and enhance their abilities to function effectively in OI teams. A climate of openness could subsequently foster improved OI competencies, encouraging trial-and-error ap-

proaches to OI practice in future organisational settings. Consequently, education promoting OI competencies may influence the level of implementation success while reducing associated challenges.

Conversely, empirical studies reveal that OI practitioners report misalignment between needed and actual OI competencies among individuals recruited for effective collaboration in OI teams (McPhillips *et al.*, 2022). Although prior studies (Table 1) address the significance of specific OI competencies, they have not examined the competency levels necessary to determine the role of HEIs in preparing future employees with essential OI capabilities. To bridge this gap, we developed and tested an OI Competence Profile to capture the general level and distribution of OI competencies among students at universities in Denmark, Poland, and Latvia. We focused on engineering students in their final year before graduation to measure baseline competency levels before the inevitable influence of organisational culture and training (Burcharth & Fosfuri, 2015), providing a comparative foundation for analysing the role of HEIs in developing OI competencies.

European HEIs have actively promoted open innovation within entrepreneurship education and encouraged exchange programs among students, which helps foster similar OI competencies across different countries. The established European Entrepreneurship Competence Framework offers a standardised approach to competency development across educational systems, potentially reducing variation in OI competencies across national borders. Zhang *et al.* (2023) suggest that while specific OI outcomes may vary across countries, fundamental competencies that drive innovation remain consistent across diverse contexts. The unique cultural and institutional characteristics of each country provide valuable insights into the development of OI competencies within different educational frameworks. However, the underlying competencies themselves should show consistency in their patterns. Moreover, business culture in developed countries is characterised by collaboration and networking, key OI competencies, which may contribute to consistent levels of OI competencies throughout Europe. HEIs face similar challenges and opportunities globally, including increased competition, evolving consumer demands, and rapid digital technology adoption. These shared contextual factors, combined with the globalising nature of knowledge exchange and educational frameworks, suggest commonalities in how OI competencies develop across different national contexts. Therefore, we hypothesised that:

H1: The levels of competencies in OI profiles is similar among engineering students across the three countries, *i.e.*, Denmark, Poland, and Latvia.

Regarding gender distribution, the relationship between OI competencies and entrepreneurship competencies is complementary. Literature suggests significant differences in entrepreneurship skills and tendencies between male and female students in Europe (Petrović & Radukić, 2018). Studies have found that male students generally demonstrate higher levels of self-efficacy, risk-taking propensity, and proactive behaviours related to entrepreneurship (Krieger *et al.*, 2022, while female students often exhibit greater networking abilities and social capital development. Gender differences in innovation competencies appear to manifest in various ways, influenced by socialisation processes, gender stereotypes, access to resources and mentorship, and disparities in confidence and self-efficacy (Zuraik *et al.*, 2020).

Traditional gender roles and socialisation patterns often encourage behaviours in male students, such as assertiveness, competitiveness, and risk-taking, that align closely with competencies valued in innovation contexts (Ehrtmann *et al.*, 2019). These socialised behaviours may lead to greater confidence in dynamic, collaborative environments typically associated with OI. Moreover, male students often benefit from greater access to mentorship opportunities and industry networks, particularly in fields where innovation activities are prominent (Leka *et al.*, 2024; Shah & Krishnan, 2023). Research also indicates that male students generally express higher confidence in their innovation capabilities, even when actual competency levels are comparable (Shinnar *et al.*, 2014).

However, these differences stem from societal factors, including gender stereotypes and discriminatory practices, rather than inherent differences in abilities or potential. Based on this literature, we hypothesised:

H2: Male students have a higher probability of being classified into higher OI profiles than female students across the countries.

By examining these hypotheses, we aimed to contribute to a deeper understanding of how OI competencies develop in educational contexts and how they may be influenced by factors such as national setting and gender. This knowledge can inform both educational practices and organisational strategies for fostering effective OI implementation.

RESEARCH METHODOLOGY

Before full-scale deployment of questionnaires across universities in the three countries, we conducted a preliminary pilot study comprising 12 in-depth semi-structured interviews with OI practitioners from innovative companies. This methodological approach aligns with recommendations by Podmetina *et al.* (2018) for developing robust competency models in OI contexts. The fundamental objective of the pilot study was to confirm the significance of each OI competence examined in our research and to establish the content validity of our measurement framework (Spurk *et al.*, 2020). Moreover, this introductory phase ensured that participants unambiguously understood all determinants employed in the study. Each interview began with a brief introduction explaining the study's purpose, followed by asking OI practitioners to identify and classify competencies that support OI activities in their projects. Based on these interviews, we selected six competencies for inclusion in the survey. 'Self-efficacy in digital technologies' was the only competence not initially included in our literature review, but emerged as significant during the pilot interviews.

Following the pilot study, we distributed an online questionnaire to students at three universities, namely the University of Southern Denmark (Denmark), Riga Technical University (Latvia), and Gdansk University of Technology (Poland). The respondents were master-level students in production engineering (management studies with an industry context), a program typical for technological universities and particularly relevant for future employees in OI teams.

We strategically selected Denmark, Latvia, and Poland as study settings to capture nuances in OI competency development across diverse economic and educational landscapes. This cross-cultural comparative approach followed methodological guidance by Buil *et al.* (2012) for ensuring meaningful comparisons between distinct national contexts. Denmark represents a mature economy with an established reputation for innovation and a robust educational system that actively integrates OI principles. Latvia and Poland, as post-transition economies where OI practices are still evolving, offer a unique opportunity to explore how emerging educational practices influence OI competencies.

We designed the survey to examine different OI competence profiles, specifically, the quantity and attributes of distinctive clusters of OI competencies across university students in the three countries, and to understand determinants connected to these clusters, particularly how gender may influence the probability of students being classified into each of the developed profiles. This focus on profiles rather than individual competencies represents a methodological advancement in understanding OI competence development, as it recognises the multidimensional and interconnected nature of these skills (Spurk *et al.*, 2020). Morin *et al.* (2015) demonstrate that the profiles derived from such analyses can offer tailored insights into group-specific characteristics, linking them to distinct response patterns observed in different populations.

We gathered data through individual online questionnaires distributed to engineering students at the three respective universities in 2022. Our sample consisted of engineering students in their final semester of master's level education, shortly before graduation. This timing is methodologically significant, as it allowed us to measure OI competency levels after full exposure to the university's educational influence but before the inevitable impact of organisational culture and training that would occur in workplace settings (Burcharth & Fosfuri, 2015). By focusing on students at the conclusion of their academic programs, we captured the cumulative effect of higher education on OI competence development, providing a more accurate assessment of HEIs' contribution to preparing future employees with essential OI capabilities. Our final sample consisted of 397 students who completed the survey, with the following distribution: Gdansk University of Technology, Poland (n=200), Riga Technical University, Latvia (n=100), and University of Southern Denmark, Denmark (n=97). The sample comprised 54.7% male students, 44.8% female students, and 0.5% who did not indicate gender. This sample size

and distribution align with recommendations for conducting Latent Profile Analysis with sufficient statistical power (Spurk *et al.*, 2020).

The survey examined students' positioning regarding OI in reference to their self-perceived abilities and dispositions associated with OI competencies. This self-assessment approach has been validated in previous studies of innovation competencies (Ovbiagbonhia *et al.*, 2023) and provides valuable insights into individuals' confidence and readiness to engage in innovative activities. We established the OI Competence Profile based on six aggregated competence constructs, supported by previous OI literature, the pilot study findings, and the ESCO framework (Table 1). We assessed the general OI Competence level through six constructs: Creativity, Communication and Networking, Entrepreneurship, Open-minded thinking, Risk-taking attitude, and Self-efficacy in Digital skills. While these skills and attitudes would individually benefit anyone participating in innovation projects, their combined profile consolidates key aspects of competence supporting effective OI performance. Each construct comprised 4-7 items, totalling 36 items. We adapted established, psychometrically validated scales to measure each construct, enhancing the reliability of our measur2ement approach. Before administering the survey, we conducted comprehensive assessments of the internal consistency reliability for all construct items by examining their Cronbach's alpha coefficients. We performed exploratory factor analysis to evaluate construct reliability and validity (see Table 2). One item was reverse-coded, which contributed to a lower Cronbach's alpha for that construct. We assessed common method bias through Harman's single-factor test, which indicated no significant bias in our data collection approach.

Table 2. Measurements of constructs

OI Competence Profile constructs	Factor loadings *α*
Creativity (Adopted from Liñán & Fernández-Serrano, 2018)	0.673
Entrepreneurship (Adopted from Liñán & Fernández-Serrano, 2018)	0.715
Communication and knowledge sharing (Adopted from Bereznoy *et al.*, 2021)	0.818
Open-minded thinking (Adopted from Lavrynenko *et al.*, 2018)	0.780
Risk-taking (Adopted from Zhang *et al.*, 2018)	0.937
Self-efficacy in digital skills (Adopted from Tierney & Farmer, 2002)	0.849

Source: own study.

To develop the OI competence Profiles and test our research hypotheses, we employed Latent Profile Analysis (LPA), a sophisticated person-centred analytical approach that identifies unobserved subgroups within a population based on response patterns across multiple indicators (Spurk *et al.*, 2020). LPA was particularly appropriate for our research objectives as it categorises individuals into profiles based on their responses to the OI competencies derived from the ESCO framework. This method excels at identifying underlying patterns in data that are not immediately apparent, allowing for the classification of competencies into empirically robust profiles. We selected a multigroup approach to account for variations across different national contexts, ensuring that the profiles reflect the specific socio-economic and educational dynamics of each country while maintaining cross-cultural comparability (Demir *et al.*, 2023).

RESULTS AND DISCUSSION

To determine the optimal number of OI profiles within each sample, we conducted several separate LPA models with two to five profile solutions. Based on multiple fit indices (AIC, BIC, AWE, CLC, and KIC), the three-profile model emerged as the best solution (see Table 3). This selection aligns with recommendations by Spurk *et al.* (2020) for balancing statistical fit with theoretical interpretability when determining profile solutions. The entropy values (ranging from 0.737 to 0.852) further indicated good classification quality across all samples, providing statistical validation for our three-profile approach. This approach allowed us to identify meaningful groupings.

We named the resultant profiles based on the mean scores of the six OI components after determining the optimal three-profile solution across all countries. Following methodological guidance from

Spurk *et al.* (2020), we designated the profiles as 'Low OI,' 'Moderate OI,' and 'High OI' since higher scores consistently correlated with higher OI competence levels across all dimensions. Table 4 presents the LPA results. Figure 1 displays the differences in measured levels of OI competencies.

Table 3. Latent Profile Analysis, fitting measures, 3 profiles

Country	AIC	BIC	AWE	CLC	KIC	Entropy
DK	383.429	428.608	602.083	333.134	412.429	0.852
LV	874.832	940.114	1133.731	824.498	903.832	0.833
PL	2657.822	2750.698	2972.099	2607.297	2686.822	0.737
ALL	3688.707	3792.223	4024.221	3638.226	3717.707	0.760

Source: own study.

Table 4. Latent class marginal means, ALL countries: DK, PL, LV; (n = 397)

Variable	Low OI (n = 49) 12.3%		Medium OI (n = 223) 56.3%		High OI (n = 125) 31.4%	
	M	*SD*	*M*	*SD*	*M*	*SD*
Creativity	2.741	0.087	3.302	0.048	3.857	0.063
Entrepreneurship	3.282	0.061	3.688	0.0403	4.147	0.044
Communication and knowledge sharing	2.942	0.083	3.695	0.043	4.299	0.060
Risk taking	2.750	0.118	3.148	0.056	3.576	0.074
Open-minded thinking	3.493	0.076	4.018	0.035	4.432	0.046
Self-efficacy in digital skills	3.067	0.087	3.754	0.055	4.381	0.053

Source: own study.

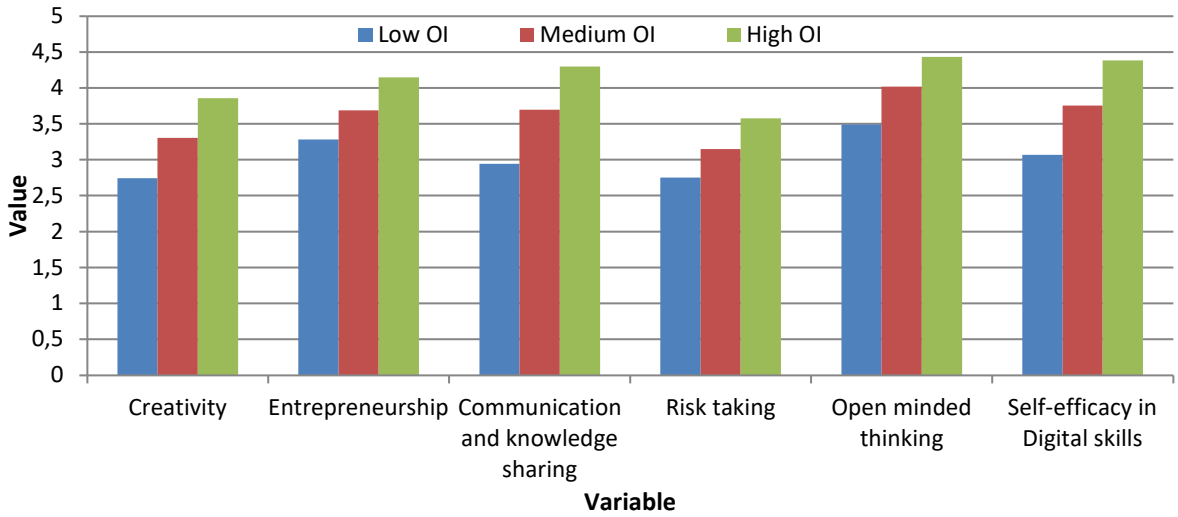

Figure 1. The differences in measured levels of OI competencies in the three profiles (High OI, Medium OI and Low OI)
Source: own elaboration, n=397.

Our findings revealed that, contrary to our first hypothesis (H1), the levels of OI competence varied significantly among the three countries. The substantial disparities in profile sizes and composition across the three sets of observations indicate that OI competencies are not uniformly distributed across different national contexts, despite shared European educational frameworks. This finding aligns with research by Akhmadi and Tsakalerou (2022), who identified persistent cultural divides in innovation practices across different European regions. As Tables 5, 6, and 7 show, there are notable variations in both profile distributions and competency patterns among Denmark, Latvia, and Poland. Tables 5, 6, and 7 (n = 397; survey data) show the profile means and profile size variations for the three countries.

Table 5. Differences in profiles: Low OI

Variable	DK (n = 12)	LV (n = 36)	PL (n = 39)	K-W p-value	Differences
Creativity	2.965	3.295	2.677	0.001	LV > DK = PL
Entrepreneurship	3.108	3.276	3.137	0.001	LV > PL = DK
Communication and knowledge sharing	3.575	3.470	2.953	0.001	DK > LV > PL
Risk taking	2.729	3.113	2.749	0.001	LV > PL = DK
Open-minded thinking	3.746	3.791	3.487	0.001	LV > DK > PL
Self-efficacy in digital skills	4.024	3.386	3.085	0.001	DK > LV > PL

Source: own study.

Table 6. Differences in profiles: Medium OI

Variable	DK (n = 16)	LV (n = 47)	PL (n = 142)	K-W p-value	Differences
Creativity	3.397	3.439	3.321	0.0167	DK = LV > PL
Entrepreneurship	3.613	3.827	3.535	0.0411	LV > DK > PL
Communication and knowledge sharing	3.566	4.065	3.676	0.0061	LV > PL > DK
Risk taking	3.254	3.653	3.135	0.0231	LV > DK > PL
Open-minded thinking	4.155	4.249	4.008	0.0490	LV > DK > PL
Self-efficacy in digital skills	3.638	4.110	3.772	0.0241	LV > PL > DK

Source: own study.

Table 7. Differences in profiles: High OI

Variable	DK (n = 14)	LV (n = 8)	PL (n = 83)	K-W p-value	Differences
Creativity	3.840	4.348	3.904	0.0008	LV > PL > DK
Entrepreneurship	4.214	4.664	4.084	0.0001	LV > DK > PL
Communication and knowledge sharing	4.606	4.543	4.244	0.0001	DK > LV > PL
Risk taking	3.872	4.297	3.339	0.0472	LV > DK > PL
Open-minded thinking	4.607	4.849	4.407	0.0001	LV > DK > PL
Self-efficacy in digital skills	4.589	4.396	4.332	0.0001	DK > LV > PL

Source: own study.

Upon examining individual competencies, we found that Latvian students demonstrated significantly higher levels of 'Entrepreneurship,' 'Risk taking,' and 'Open-minded thinking' competencies across all profiles compared to Danish and Polish students. This pattern may reflect Latvia's educational emphasis on entrepreneurial mindsets and risk-taking as essential components for economic development in post-transition contexts (Kubiv *et al.*, 2020). Conversely, Danish students exhibited notably higher competence in digital skills compared to their Polish and Latvian counterparts, particularly in the Low and High OI profiles. This digital competency advantage aligns with Denmark's advanced digital infrastructure and educational focus on technological integration (van Kessel *et al.*, 2022). Polish students displayed relatively consistent, moderate levels of competencies across all profiles, suggesting a more standardised approach to education that may not emphasise the extremes of either high or low competence development in specific areas.

Noteworthy, despite differences in individual levels of specific competencies, the advantage of the OI Competence Profile is to evaluate these elements as an aggregated index, reflecting OI managers' need for recruiting employees with a full range of OI competences, each presented at a significant level.

We may attribute the observed differences in OI competencies among students across the three countries to several factors. Educational systems significantly impact competency development, with some systems placing stronger emphasis on OI-related skills than others (Spada *et al.*, 2022). Curriculum variations across universities and countries substantially influence competency development, with

certain national educational contexts focusing more intensively on sectors requiring higher OI competencies (Gürdür Broo *et al.*, 2022).

Furthermore, governmental support for innovation varies considerably across countries. Mature economies like Denmark typically provide more substantial funding and resources for innovation projects (Markovic *et al.*, 2021), creating more fertile environments for OI competency development. Some differences may also stem from varying levels of systemic digitalisation across the three countries. While Industry 4.0 implementation is widespread in Denmark, it remains more limited in Poland and Latvia (Honti *et al.*, 2020), affecting the development of digital competencies essential for OI practices. Overall, the level of OI competencies among students is influenced by multiple interacting factors that collectively shape competency development within each national context.

We also examined gender as a predictor of OI Competence levels. Contrary to our second hypothesis (H2), which proposed that male students would have a higher probability of being classified into higher OI profiles, our findings revealed a more complex gender landscape across the three countries. While male students were indeed more likely to appear in the High OI profile when considering the overall sample (66.4% men vs. 33.6% women), country-specific analyses revealed significant variations in this pattern (Tables 8-11).

Table 8. Profile differences by gender (percentages), all countries: DK, PL, LV

Variable	Low OI (n = 49)	Medium OI (n = 223)	High OI (n = 125)
Female	59.18	47.98	33.60
Male	40.78	52.02	66.40
Prefer not to say	0.04	0.004	0.00

Source: own study.

Table 9. Profile differences by gender (percentages): DK

Variable	Low OI (n = 12)	Medium OI (n = 16)	High OI (n = 14)
Female	41.60	62.50	28.57
Male	58.40	37.50	71.42

Source: own study.

Table 10. Profile differences by gender (percentages): PL

Variable	Low OI (n = 39)	Medium OI (n = 142)	High OI (n = 83)
Female	53.85	55.63	68.67
Male	46.40	44.36	31.33
Prefer not to say	0.05	0.01	0.00

Source: own study.

Table 11. Profile differences by gender (percentages): LV

Variable	Low OI (n = 36)	Medium OI (n = 47)	High OI (n = 8)
Female	55.50	57.44	62.50
Male	44.50	42.56	37.50

Source: own study.

In Denmark, our findings aligned with H2, showing a strong male representation (71.42%) in the High OI Profile. This suggests potential gender disparities in encouragement or confidence among Danish students within high-stakes innovation environments. This pattern aligns with research by Krieger *et al.* (2022) on gendered educational outcomes in Nordic countries. However, contrary to our hypothesis (H2), Poland showed predominant female representation in the High OI Profile (68.67%), with this trend persisting in the Medium OI Profile (55.63%). This unexpected finding indicates robust engagement of

women in high-level innovation activities in the Polish educational context. Similarly, Latvian female students demonstrated higher OI competencies than male students, with increasing female representation as profile levels increased (55.5% in Low OI, 57.44% in Medium OI, and 62.5% in High OI).

These contrasting gender patterns across countries led us to reject H2 in its generalised form, suggesting that cultural context plays a significant moderating role in the relationship between gender and OI competencies. This finding highlights the importance of contextually sensitive approaches when examining gender dynamics in innovation contexts.

We may explain these contrasting gender patterns across countries through several theoretical lenses. As suggested by Antonelli *et al.* (2023), educational systems in post-transition economies like Poland and Latvia may emphasise collaborative and community-oriented projects that more effectively engage female students in innovative practices. The pedagogical approaches in these countries might better integrate gender-specific experiences and challenges into learning environments, yielding higher OI competency profiles among women.

Conversely, Denmark's highly egalitarian but well-established educational system may present a different landscape where different factors influence gender distinctions in competencies. As Lapuente and Suzuki (2020) suggest, in contexts with well-established gender equality, the pressures and incentives for female students to demonstrate higher innovation competencies may differ from those in countries still actively addressing gender disparities.

These gender-related findings highlight the complex interplay of cultural factors, educational systems, leadership opportunities, and societal expectations in shaping OI competence development across different national contexts. This complexity underscores the need for contextually sensitive approaches when developing educational strategies aimed at fostering OI competencies among diverse student populations.

CONCLUSIONS

This study provides a comprehensive analysis of open innovation competence among university students, employing dynamic capabilities theory to categorise and understand the varying distributions of OI competencies across higher education contexts in Denmark, Latvia, and Poland.

From the perspective of dynamic capabilities theory (Teece, 2020), our study makes several significant contributions to OI research. Firstly, the development of an OI Competence Profile represents a first-order dynamic capability that contributes to competitive advantage by enabling organisations to better identify and develop essential innovation skills (El Maalouf *et al.*, 2022). By adopting a profile approach that integrates distinct yet complementary competencies, we provide a more holistic framework for understanding how these capabilities collectively enhance innovation practices.

Secondly, our cross-national comparison reveals important insights into how educational, cultural, and economic contexts shape OI competency development. Contrary to our first hypothesis, we found significant variations in OI competence profiles across the three countries, suggesting that despite shared European educational frameworks, national contexts substantially influence innovation competency development. Latvian students demonstrated notably higher levels of entrepreneurship, risk-taking, and open-minded thinking, while Danish students excelled in digital competencies, and Polish students showed consistent moderate levels across all dimensions.

Thirdly, our gender analysis uncovered unexpected patterns that challenge conventional assumptions about gender and innovation. While our aggregate data showed male students were more likely to appear in high OI profiles overall, country-specific analyses revealed that female students in Poland and Latvia were significantly more represented in high OI profiles than their male counterparts. Only in Denmark did we observe the expected male predominance in high OI profiles. These findings highlight the complex interaction between gender, educational systems, and cultural contexts in shaping innovation competencies (Krieger *et al.,* 2022; Zuraik *et al.*, 2020).

Our research contributes to the OI literature by conceptualising and measuring OI competencies at the individual level before organisational influence, providing an important baseline for under-

standing how these capabilities develop through educational experiences. The multi-country, gender-inclusive approach offers nuanced insights into how national educational systems and cultural factors influence OI competency development, addressing significant gaps in existing literature that has typically examined these issues in isolated contexts.

From a practical perspective, our findings provide valuable insights for both educational institutions and industry practitioners. For higher education institutions, our results emphasise the need to create targeted OI learning contexts during tertiary education that account for specific national and cultural factors. Universities should consider integrating practical experiences, collaborative projects, and digital skill development into their curricula, while remaining attentive to potential gender disparities in innovation education (Ovbiagbonhia *et al.*, 2023).

For practitioners, our OI Competence Profile offers a framework for identifying and developing key competencies in potential and current employees. Organisations can use this profile to guide recruitment strategies and professional development initiatives, particularly when assembling diverse teams for OI projects (Podmetina *et al.*, 2018). The country and gender variations we observed suggest that organisations should adopt contextually sensitive approaches to talent development and avoid one-size-fits-all strategies when operating across different national contexts.

Our study has several limitations that present opportunities for future research. First, while our sample provides meaningful insights into three European countries, expanding this research to include a broader range of countries, including non-European contexts, would enhance the understanding of how cultural and economic factors influence OI competency development globally. Secondly, longitudinal studies tracking how OI competencies evolve from university into professional settings would provide valuable insights into the long-term impact of educational interventions. Thirdly, a deeper investigation into the specific educational practices and cultural factors that contribute to the observed gender differences could yield important insights for designing more inclusive innovation education.

Future research could also explore how specific pedagogical approaches, such as project-based learning, industry collaborations, and experiential learning environments, influence the development of OI competencies. Moreover, examining how digital transformation in education affects OI competency development represents an important avenue for further investigation.

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Use of Artificial Intelligence

This text is free of AI/GAI usage except for grammar and spell-checking performed with Grammarly.

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