Digital entrepreneurial practices in automobile-transport vocational education

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Abstract. The digitalisation of road transport and logistics is reshaping the work of automobile-transport college graduates, yet the pedagogical literature tends to catalogue digital *tools* rather than the entrepreneurial *actions* those tools should serve, and no evidence-based taxonomy links practice types to competence outcomes for this sector. This study derives such a taxonomy through a two-stage design: a PRISMA-ScR scoping review that maps a heterogeneous, cross-disciplinary evidence base, followed by best-fit framework synthesis that codes the extracted practices against an a-priori frame of entrepreneurial-competence areas and entrepreneurial-action stages. From an initial 320 records, 63 sources were retained; the 22 practice-exemplifying sources among them were classified into groups by two independent coding passes that agreed closely (Cohen's $\kappa = 0.94$ for group assignment); as both passes were AI-generated, this indexes coding-scheme consistency rather than independent human-rater reliability. Four groups of digital entrepreneurial practice are distinguished: (1) project-based entrepreneurial, (2) technical–economic, (3) logistical–organizational, and (4) communicative–reflective practices. The first three are each supported by at least three independent sector or pedagogy studies; the fourth is warranted by the completeness of the entrepreneurial-action cycle together with cross-sector reflection and assessment scholarship, an evidential asymmetry we report rather than smooth over. The four groups span a coherent cycle of entrepreneurial action – a structure partly entailed by the analytic frame – and are mapped onto the EU EntreComp and DigComp frameworks and onto experiential and activity-learning theory. Two conceptual moves extend the taxonomy into a framework: a *trace–reflection mechanism*, in which each action leaves an inspectable digital artefact that mediates assessment and revision, and a two-dimensional *practice-design space* that positions each group against tiers of environment fidelity and treats immersive technology as a level of that dimension rather than a separate group. Eight testable propositions and a progression-anchored assessment rubric are proposed. The contribution is conceptual and design-oriented; the framework and rubric await empirical validation.

Keywords: entrepreneurial competence, digital entrepreneurial practices, automobile-transport vocational education, scoping review, EntreComp, DigComp, experiential learning, simulation and immersive learning

1. Introduction

The professional training of students in automobile-transport colleges – vocational institutions spanning professional (vocational) and professional pre-higher education (roughly ISCED 3–5 / EQF 3–5) that prepare road-transport technicians, logisticians, and service specialists – is being reshaped by the digitalisation of managerial, logistical, service, and communication processes across the transport sector [21, 42]. As routing, costing, fleet management, and client interaction migrate to digital platforms, employers increasingly expect graduates not only to perform technical operations but also to work with digital data, assess costs and risks, organise service delivery, and make substantiated entrepreneurial decisions [9, 51]. For a sector central to Ukraine's economic recovery

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and its integration into the European transport area, this shift makes entrepreneurial capability a training priority rather than an optional supplement [39, 43].

A well-developed research base supports the general case. Entrepreneurial competence is developed through experiential, practice-based learning rather than through instruction about entrepreneurship [47, 49, 53]; the European frameworks specify what entrepreneurial (EntreComp) and digital (DigComp) competences comprise [2, 63]; and transport and logistics processes can now be modelled at high fidelity through simulation and digital twins [25, 37]. These strands, however, remain unintegrated at the level of the vocational classroom. Studies of digital entrepreneurship education tend to enumerate the tools that appear in courses [19, 23, 60] rather than the entrepreneurial actions those tools serve; no evidence-derived taxonomy links practice *types* to competence outcomes in transport-sector vocational education; and there is no assessment logic for the digital artefacts such practices generate. The result is a field organised around technology rather than around learning, in which "using a digital tool" is too readily equated with "developing entrepreneurial competence."

The aim of this study is to derive, from the literature, an evidence-grounded taxonomy of *digital entrepreneurial practices* for automobile-transport vocational education, and to embed it in a competence-grounded conceptual framework with testable propositions and a proposed assessment rubric. The study addresses five research questions:

RQ1. How is the construct *digital entrepreneurial practice* defined and delimited across entrepreneurship education, vocational education and training (VET), and the digital transformation of transport and logistics?

RQ2. What groups of digital entrepreneurial practices can be derived from the literature for automobile-transport VET, and what evidence supports each?

RQ3. How do the derived groups map onto the EntreComp and DigComp/DigCompEdu frameworks and onto experiential and activity-learning theory, and where does the construct exceed those frameworks?

RQ4. Which digital, simulation, and immersive environments enable each group, and under what conditions do they *develop* rather than merely *demonstrate* entrepreneurial competence?

RQ5. How can the digital artefacts of these practices be assessed, and what testable propositions link the taxonomy to competence development?

The study makes the following contributions. (1) We are not aware of a prior taxonomy of digital entrepreneurial practices for automobile-transport VET; this study derives one through a scoping review (a claim bounded, as section 6 notes, by the databases searched, which did not include Scopus, Web of Science, or ERIC). (2) It defines the construct and fixes its differentia as the entrepreneurial action modelled, not the tool employed. (3) It distinguishes four practice groups – three supported by at least three independent sources and a fourth warranted by cycle completeness and corroborating scholarship – and reports the procedural consistency of the group assignment. (4) It introduces a *trace–reflection mechanism* and a two-dimensional *practice-design space* that together turn the taxonomy into a framework. (5) It maps the framework onto EntreComp and DigComp and states explicitly what those frameworks do not specify. (6) It advances eight testable propositions and a progression-anchored assessment rubric to guide validation and practice.

2. Background

Three literatures bear on the problem. The first concerns *entrepreneurial competence and its development*. Entrepreneurship education research has moved from teaching *about* enterprise toward teaching *through* enterprise, emphasising experiential and project-based activity as the mechanism of competence formation [36, 49, 53], even as the impact-measurement literature cautions that the evidence for these effects is methodologically uneven [47]. Competence models have been consolidated at European level in EntreComp, which organises entrepreneurial competence into the areas of *ideas and opportunities*, *resources*, and *into action* [2, 3, 5], and empirical work has elaborated the core competencies and their interdependencies, including the present authors' account of its professional and personal dimensions [35, 40, 57, 65]. This tradition establishes *what* is to be developed but says little about the sector-specific practices through which it is developed.

The second literature concerns *digital entrepreneurship and its education*. Digital technologies are recognised as reshaping the entrepreneurial process itself – its opportunities, artefacts, and business models [4, 16, 33, 48] – and a growing body of work examines how education should respond, through digital entrepreneurship courses, gamified venture creation, and simulations [19, 20, 26, 60, 64]. In vocational settings specifically, studies report the development of conceptual models for entrepreneurial-skill formation, analyses of student-entrepreneurship practice, and evidence on vocational students' digital-entrepreneurial dispositions [14, 24, 32, 58, 61]. A recurring limitation is that this work maps *tools* onto competences [23] without specifying the practices that connect them.

The third literature concerns the *digital transformation of transport and logistics education*. Simulation, discrete-event modelling, and digital twins are now used to represent routing, scheduling, and supply-chain operations [25, 37, 50], and digital twins and virtual learning environments are entering engineering and manufacturing education as pedagogical instruments [22, 34]. In parallel, immersive virtual, augmented, and mixed reality is used to develop technical and self-regulatory skills in vocational training [7, 8, 13, 29, 52, 66]. This literature supplies powerful environments but frames them around technical skill or system modelling, not around entrepreneurial action.

The gap that motivates the present study lies at the intersection of the three: there is no framework that connects the digital tools and environments of the transport sector to the *entrepreneurial actions* an automobile-transport graduate must perform, expressed as teachable, assessable practices grounded in a competence model.

Because "digital entrepreneurial practice" sits near several established constructs, we delimit it at the outset. It is not *digital competence*, which is an antecedent capability to use technology [63]: possessing digital skills does not entail modelling an entrepreneurial action. It is not *entrepreneurship simulation*, which we treat as one tier of a fidelity dimension (§4) rather than as the construct itself [20]. It is not *digital entrepreneurship*, which is the target real-world activity [48], whereas a digital entrepreneurial practice is the *pedagogical* activity that rehearses it. Following practice theory, we treat a *practice* – a routinised, tool-mediated, socially recognisable doing – rather than a tool as the unit of analysis [55].

3. Methods

3.1. Design rationale

The study uses a two-stage design. Stage 1 is a *scoping review* reported against the PRISMA extension for scoping reviews (PRISMA-ScR) [62], following the Arksey and O'Malley framework as advanced by Levac and colleagues [1, 38]. A scoping review, rather than a systematic review or a narrative essay, fits the aim: the evidence base is emerging, heterogeneous, and spread across disciplines, and the objective is to map it and derive a construct, not to estimate the effect of an intervention [46]. Stage 2 is *best-fit framework synthesis* [11, 12]: extracted practices are coded against an a-priori frame formed by crossing the EntreComp competence areas [2] with the phases of an entrepreneurial-action cycle, and any practice the frame cannot accommodate generates a new, emergent theme reported as such. This design names the step – from charted data to derived groups – at which a narrative review would rely on the author's judgement alone, and subjects it to an explicit coding frame, a support threshold, and a reliability check. Because the frame is built from EntreComp and an action cycle, and because the authors' earlier descriptive account had already asserted a four-part structure (treated here only as a *sensitising* frame, not as an a-priori coding scheme), the four-fold result is partly entailed by the design; best-fit framework synthesis is, accordingly, a method for *structuring and testing* candidate groups against evidence rather than for discovering them *ex nihilo*. What the synthesis adds, and what could have failed, is whether each candidate group cleared the support threshold, which candidates were reclassified or rejected (section 4.1), and how the groups instantiate in the transport sector.

3.2. Realm, databases, and search

The realm comprised peer-reviewed literature and high-credibility framework and policy documents at the intersection of entrepreneurship education, VET, digital entrepreneurship, competence frameworks, and the digital transformation of transport and logistics education. Searches were run in July 2026 across Semantic Scholar and Crossref (through a federated academic-search interface), the Wiley Online Library, PubMed (for methodological and psychometric works), and – for two foundational transport records – arXiv, with document identifiers resolved through the publishers and, for the European framework reports, through the EU Publications Office. Ten thematic search strings combined the core construct with entrepreneurship-education, VET, competence-framework, digital-twin, immersive-learning, and methodology blocks; the full query log is retained as an audit trail. The primary window was 2020–2026, with foundational and methodological works retained irrespective of date. Scopus, Web of Science, and ERIC were not accessible in the present environment, and the Consensus research engine was unavailable; these constraints are acknowledged in the limitations. Searching within each theme stopped when further queries returned no new candidate practice type [59].

3.3. Eligibility and screening

Sources were included if they were peer-reviewed or high-credibility framework/policy documents; addressed entrepreneurial competence, digital entrepreneurship, VET, or digital, simulation, and immersive learning relevant to transport and logistics; and offered at least one of a definition, a practice or activity type, a tool-to-task link, an assessment cue, or a competence-framework mapping. Vendor and product-download pages were excluded (tools are named in prose without citation), as were records with no learning dimension, no retrievable full text or metadata, or predatory provenance. Figure 1 reports the flow. Consistent with a scoping review, the sample is purposive rather than exhaustive. Of 320 records identified, 279 remained after duplicate removal; title/abstract screening excluded 176; of 103 records assessed in full, 40 were excluded (chiefly non-credible venues and unverifiable metadata); 63 were retained. Of these 63, 22 were charted as *practice-exemplifying* sources – the basis of the taxonomy and of the reliability check – and 41 were *corroborating* framework, theory, method, and context works; a further 3 methodological and canonical references (e.g., [6, 15]) are cited outside the screened corpus, giving 66 references in total. The retained corpus spanned seven disciplines (entrepreneurship and management; education and VET; educational technology and learning sciences; transport, logistics, and engineering; research methodology and measurement; social theory; and competence-framework/policy studies); Ukrainian-context sources accounted for 7 of 63 (≈11%, counting the Ukrainian-authored self-citation) and self-citations for 2.

3.4. Charting, the support threshold, and reliability

Each source was charted for bibliographic details, discipline, education level, the entrepreneurial action addressed, the digital-tool class, the environment-fidelity tier, the EntreComp and DigComp areas engaged, the learning-theory anchor, the artefact or trace produced, and any assessment cue. A candidate practice *group* was retained as defining only where supported by at least three *independent* sources – peer-reviewed or scholarly works by different author teams; policy and framework instruments corroborated but did not count toward the threshold. Support was recorded separately as Tier-1 (cross-sector, warranting the group's structure) and Tier-2 (transport-logistics-specific, warranting its sector instantiation). To check the stability of the group assignment, the 22 practice-exemplifying sources were classified into the group each most directly exemplified by two independent coding passes run in separate, mutually blind contexts. Both passes were AI-generated (see the Declaration on Generative AI); the resulting statistic therefore indexes the *procedural*

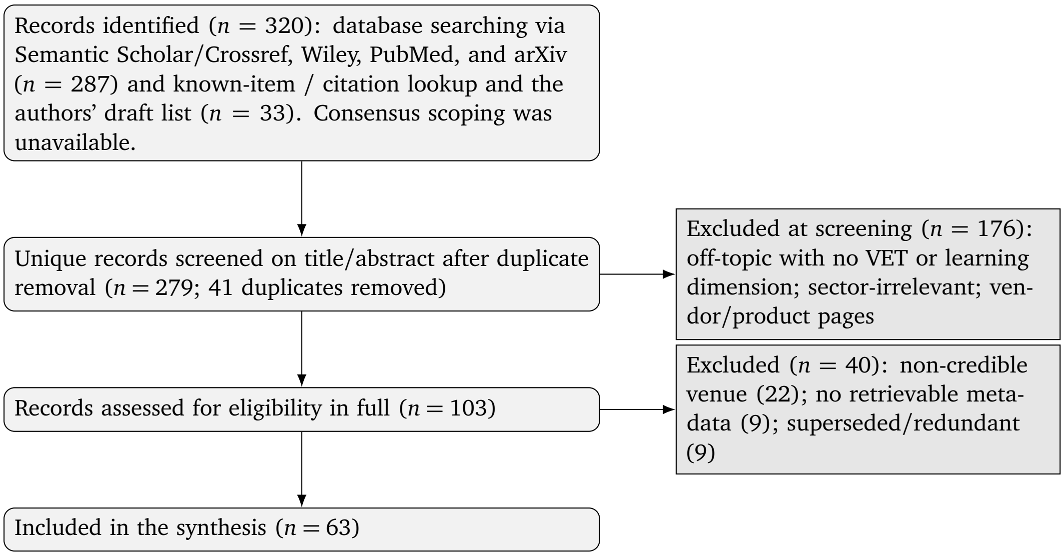

Figure 1: PRISMA-ScR flow of source identification and selection. As a scoping review with a purposive rather than exhaustive sample, the flow documents transparency, not systematic-review completeness; identification totals aggregate the thematic searches.

consistency of the coding scheme rather than human inter-rater reliability, and cannot detect biases the two passes may share. Observed agreement was 95.5% and Cohen's κ for group assignment was 0.94 (computed before consensus resolution) [15]. Because N is small (22) and the marginal distribution is skewed, this figure is prevalence-sensitive and fragile to a single reclassification – one further disagreement would lower it to about 0.88 [41] – and it covers only the group-assignment variable, not the screening, threshold, or tier-coding decisions, which were not double-coded. The single disagreement – an immersive-VR workspace-design study read as organizational by one pass and technical by the other – was resolved to the logistical–organizational group. Sensitivity of the taxonomy to the threshold (≥ 2, ≥ 3, ≥ 4 sources) was examined and is reported with the results.

3.5. Rigour, reflexivity, and ethics

Trustworthiness was supported by an a-priori protocol fixed before searching, a retained query log and coding matrix, analytic memoing, a disconfirmation audit that recorded candidate practice types *not* retained, and the double-coding above. The authors are situated within the Ukrainian vocational system, which afforded contextual insight but risked over-reading the sector's needs into the corpus; the a-priori frame and the independence rule were adopted to constrain this. The study analysed published literature only: it involved no human participants, no personal data, and no primary data collection, and the learning cases presented in section 4 are constructed illustrations, not studies of identifiable individuals.

4. Results

4.1. From asserted principles to derived groups

The corpus consistently frames effective entrepreneurship pedagogy as experiential, artefact-producing, and progressively authentic [26, 49, 54]. Coding the extracted practices against the a-priori frame yielded four groups, and no additional group cleared the support threshold in the searched corpus: candidate types such as digital-marketing and data-analytics practices folded into one or more of the four groups, while regulatory-compliance practices – arguably central to transport entrepreneurship (licensing, cabotage, dangerous-goods, tachograph rules) – surfaced in only one source and were recorded as a coverage-limited candidate for future work rather than as a group; this is a limitation of a search that did not include Scopus, Web of Science, or ERIC, not a demonstration of exhaustiveness. The construct that organises the four groups is defined as follows: a *digital entrepreneurial practice* is a professionally-oriented learning activity in which a student models, performs, and analyses an entrepreneurial action of the automobile-transport domain through digital tools, such that the action leaves an inspectable digital artefact that mediates feedback, assessment, and revision. The differentia is that the tool is subordinate to the modelled action: operationally, an activity fails the test when its assessable output is a demonstration of tool proficiency (a formatted document, a completed tutorial) rather than an artefact or decision that answers an entrepreneurial question.

4.2. The four groups and the practice-design space

The four groups are project-based entrepreneurial (G1), technical–economic (G2), logistical–organizational (G3), and communicative–reflective (G4) practices. They are four phases of entrepreneurial action – opportunity formation, feasibility substantiation, operational implementation, and market interaction with reflection – that together span the entrepreneurial-action space. As noted in section 3.1, this four-fold structure is partly entailed by the analytic frame and by the authors' sensitising prior account; the synthesis instantiates and tests it rather than discovering it. The ordering G1 → G2 → G3 → G4 reflects one defensible action logic; non-linear and effectual accounts of entrepreneurship would sequence the same phases differently [49]. The groups are analytically distinct but *not* mutually exclusive: a single practice may engage more than one – a gamified venture with a live store engages both project-based and technical–economic practice – and the derivation charted sources under multiple groups accordingly, so the per-group source tallies below share some sources.

The evidence is uneven across groups, and we report it as such. Applying the ≥ 3-independent-source rule (peer-reviewed works by different teams; theory, method, and framework works corroborate but do not count) and, crucially, separating support for a group's *content* from support for the fidelity dimension, the project-based (G1), technical–economic (G2), and logistical–organizational (G3) groups each clear three independent sector or pedagogy studies. G3 is the most strongly sector-grounded (four transport-logistics studies [21, 25, 37, 50]). The immersive-VR technical-skill studies [7, 13, 66] evidence the *fidelity dimension* – that vocational skills are rehearsed in immersive environments – not the economic content of G2, and are counted only toward the former; G2's economic content rests on [9, 20, 26] together with the digital-twin modelling studies [22, 34]. The communicative–reflective group (G4) is the weakest link: setting aside theory and method works as the rule requires, it rests on essentially two direct practice studies [40, 52], together with the completeness of the action cycle and corroborating reflection and assessment scholarship, and it has *no* transport-specific study. This double asymmetry – thin, and non-sector-specific – is disclosed here, in the coding matrix, and in the limitations rather than smoothed over.

A taxonomy of groups is, on its own, one-dimensional. The corpus indicates that the *same* entrepreneurial action can be rehearsed at very different levels of authenticity – with generic digital tools, in a simulation, in a digital twin or immersive environment, or on a real-market platform [20, 26, 29, 34]. Crossing the four groups with these tiers of environment fidelity yields a two-dimensional *practice-design space* (figure 2). The design space locates each concrete practice as a cell rather than a point, and it treats immersive technology as a *level* of the fidelity dimension rather than a fifth group. This is a modelling choice, not a discovery; its justification is that separating the *environment* in which a practice runs from the entrepreneurial *action* it rehearses dissolves a recurring conflation in the literature, under which "adding VR" is mistaken for adding a new kind of entrepreneurial practice. The fidelity axis also describes a progression from low-fidelity familiarisation to real-market performance that later informs the assessment rubric.

4.3. Group 1: project-based entrepreneurial practices

Project-based practices engage the EntreComp area of *ideas and opportunities*: identifying a transport-service need, forming a value proposition, and presenting a service digitally [26, 49, 64]. In the

	Generic digital tools	Simulation	Digital twin / immersive	Real-market platform
G1 Project-based	Idea map, Business Model Canvas, landing page	Venture/business game, gamified store	AR/VR service pitch; VR service-space model	Live e-commerce offer; real pitch to clients
G2 Technical–economic	Cost/price spreadsheet; economic note	Cost/risk scenario simulation	Digital-twin cost/throughput model	Real quotation and tender
G3 Logistical–organizational	Route/schedule on digital maps	Discrete-event / Petri-net logistics sim	Transport digital twin of operations	Live TMS dispatch
G4 Communicative–reflective	Offer page, CRM message, reflective note	Simulated client dialogue	Immersive client interaction; SRL prompts	Real client feedback loop

increasing environment fidelity / authenticity (familiarisation → capstone)

Figure 2: The practice-design space: the four practice groups (rows) crossed with tiers of environment fidelity (columns). Cells are practice archetypes drawn from the corpus and from tables 1–3. Immersive technology appears as a fidelity tier, not a fifth group; the fidelity axis marks a progression that informs the rubric (table 6).

automobile-transport domain they range from identifying a local service gap to modelling a service space in virtual reality and pitching a venture. Table 1 sets out representative learning cases, the student tasks, indicative digital tools, and the target artefact each is designed to produce; the artefact, not the tool, is the object of assessment.

4.4. Group 2: technical–economic practices

Technical–economic practices engage the EntreComp area of *resources*: calculating the resources, costs, and risks of a transport service and substantiating its feasibility [22, 26, 34]. Digital and simulation tools support quantitative modelling; where a digital twin represents a service's throughput or cost structure, the practice sits at a higher fidelity tier of the same group. Table 2 shows the task types with worked automobile-transport examples. Tools such as spreadsheet and discrete-event simulation environments are named as exemplars in the text rather than cited as sources.

4.5. Group 3: logistical–organizational practices

Logistical–organizational practices engage the EntreComp area of *into action* – planning, and coping with uncertainty and risk – through the organisation of routes, schedules, and transport processes [21, 25, 37, 50]. This group has the strongest sector-specific evidence, because transport routing and logistics are exactly where digital twins and discrete-event simulation are most developed. The logic of such a practice can be expressed as a cycle from order analysis to a substantiated decision, with iteration when conditions change (figure 3).

4.6. Group 4: communicative–reflective practices and the trace–reflection mechanism

Communicative–reflective practices engage the EntreComp competences of *working with others* and *learning through experience*: interacting with clients, handling feedback, and evaluating one's own decisions [40, 52]. This group also carries the framework's central mechanism. What makes a

Table 1
Project-based entrepreneurial digital practices: learning cases, student tasks, digital tools, and target artefacts.

Learning case	Tasks for students	Digital tools (examples)	Target digital artefact
A new transport service for the community	Identify a relevant local transport need; propose a service; describe its consumer, advantages, and mode of delivery	Google/Microsoft Forms, Padlet, Miro, Canva	Idea map; short service presentation
Mobile on-site service for the client	Design an on-site service (technical assistance, diagnostics, seasonal maintenance); define ordering and client communication	Canva, Google Sites, Genially, online forms	Service-page prototype; customer-journey scheme
Digital customer journey	Describe the journey from need to service delivery; mark digital touchpoints: search, ordering, payment, feedback	Miro, FigJam, Lucidchart	Customer-journey map
Online service offer	Create a digital offer: title, description, advantages, ordering conditions, indicative cost, contacts	Canva, Google Sites, Wix, Tilda	Landing/advertising page layout
Business idea for a small enterprise	Complete a simplified business-model template: clients, service, resources, partners, costs, revenue, promotion	Business Model Canvas online, Notion, Google Sheets	Digital business-model template
AR presentation of a service	Show service elements via augmented reality; explain client benefits	CoSpaces Edu, Assemblr EDU, ZapWorks	AR demonstration of the service
VR model of the service space	Model the space of a future service: service area, reception point, logistics hub	CoSpaces Edu, Spatial, WebXR viewers	Virtual model / short VR walkthrough
Pitch of an entrepreneurial idea	Prepare a short pitch: audience, advantages, digital channels, expected outcome	Canva, Prezi, Loom, video editors	Video pitch / interactive presentation

Table 2
Technical–economic digital practices: task types with automobile-transport worked examples.

Task type	Content	Automobile-transport example	Digital product
Resource and cost modelling	Determine the resources, costs, and conditions required to deliver a service	Compute the cost of a transport service given fuel, time, labour, and maintenance	Resource/cost table; economic note
Price and profitability modelling	Set a price given prime cost, market conditions, and expected profit	Set the price of a transport offer and justify its competitiveness	Digital pricing model
Scenario-based risk modelling	Analyse how the outcome changes under different conditions (costs, demand, delays, faults)	Compare profitability if fuel prices rise or orders fall	Scenario table; risk matrix
Technical–economic substantiation	Compare several courses of action and select the most appropriate	Choose between own transport, rental, partnership, or a digital planning service	Comparative table; reasoned conclusion

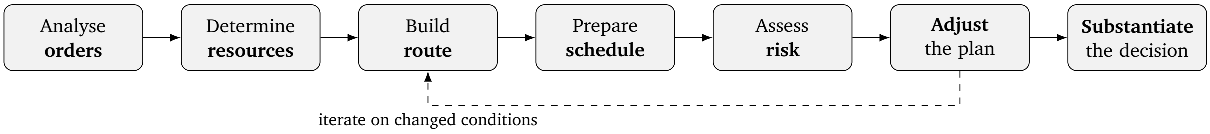

Figure 3: Logic of a logistical–organizational digital practice: a cycle from order analysis to a substantiated decision, with iteration when conditions change. In higher-fidelity tiers the cycle runs on a discrete-event model or a transport digital twin.

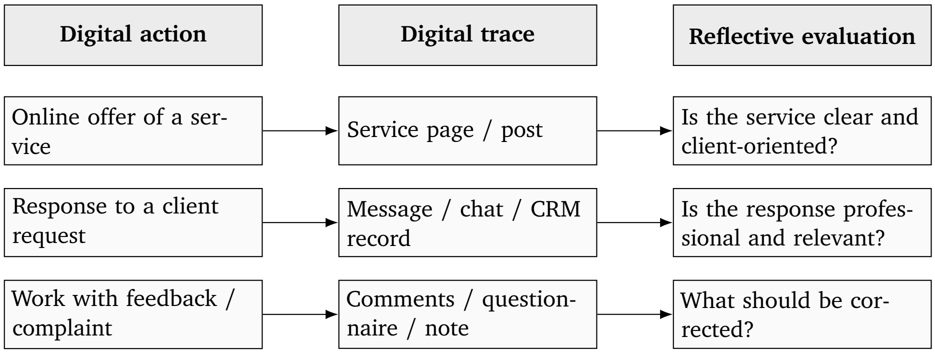

Figure 4: The trace–reflection mechanism at the micro level: each entrepreneurial action leaves an inspectable digital trace that mediates reflective evaluation and revision.

practice *digitally* entrepreneurial, across all four groups, is that each entrepreneurial action leaves an inspectable *digital trace* – a page layout, a message, a model, a pitch – and it is the trace, not the tool, that can be examined, questioned, and revised. The digital character of the trace matters because, unlike a paper canvas or an ephemeral spoken pitch, a digital artefact is versioned, timestamped, machine-inspectable, and shareable, so the reasoning behind an entrepreneurial decision can be reconstructed, compared across iterations, and assessed at scale. Figure 4 renders this trace–reflection mechanism at the micro level, and table 3 sets out the matrix of action, trace, reflective question, and possible result. Because the mechanism produces an artefact for every action, it is also what makes the practices assessable, which the rubric below exploits.

Table 3
Communicative–reflective digital practices: the action–trace–reflection matrix.

Student action	Digital trace	Reflective question	Possible result
Create an online service offer	Page layout, advertising post, service description	Is it clear to the client what problem the service solves and what its advantage is?	Clarified value proposition; revised service description
Model a response to a client request	Chat, email, messenger message, CRM-style record	Is the response professional, accurate, persuasive, and client-oriented?	Corrected communication style; clarified conditions
Work with feedback or complaints	Comments, questionnaires, ratings, request screenshots	What problems does the client see, and what should change?	List of corrective actions; updated offer
Prepare a video pitch or digital presentation	Video, slides, interactive presentation, AR/VR demo	Is the entrepreneurial decision presented with sufficient argument?	Revised presentation; strengthened argument
Analyse the results of a learning case	Reflective map, analytical report, self-assessment	Which decision was effective, what errors occurred, how to correct them?	Conclusion on decision quality and ways to improve it

5. Discussion

5.1. A complete cycle mapped onto competence frameworks

Read together, the four groups trace one cycle of entrepreneurial action and collectively engage competences across the three EntreComp areas, and they span – though they do not traverse in canonical order – the modes of Kolb's experiential-learning cycle [2, 30, 31]. Two qualifications follow. First, EntreComp has three areas, not four, so the mapping is not one-to-one: G3 and G4 both draw on the *into action* area but on different competences within it (planning and coping with uncertainty for G3; working with others and learning through experience for G4). Second, the four practice groups touch all four Kolb modes as a set but do not run in Kolb's sequence (concrete experience, reflective observation, abstract conceptualisation, active experimentation); the G1→G2→G3→G4 order follows the action logic, not the learning-cycle order, and we do not claim the two coincide. Table 4 sets out the mapping and, in its final column, states what the competence frameworks do *not* specify. This delta is the substance of the contribution beyond a restatement of EntreComp: the frameworks name competences but not the sector-instantiated practice types that develop them, nor the digital artefacts that evidence them, nor a fidelity progression along which they mature. Activity theory motivates treating each practice as a mediated system in which the digital tool is the mediating artefact between the student and a substantiated entrepreneurial decision [17, 45, 55], and the TPACK framework explains why pedagogical value emerges only where technological, pedagogical, and content knowledge intersect – the principle we render as "task over tool" [44].

Table 4
Mapping the four practice groups onto competence frameworks and learning theory, with the delta the frameworks do not specify.

Group	EntreComp competences (area)	DigComp area (predom.)	Kolb mode	Delta: not specified by the frameworks
G1 Project-based	Spotting opportunities; valuing ideas (*Ideas and opportunities*)	Digital content creation	Concrete experience	The sector practice type (transport-service ideation) and its assessable artefact
G2 Technical–economic	Financial and economic literacy; mobilising resources (*Resources*)	Information and data literacy	Abstract conceptualisation	Quantitative transport cost/risk modelling artefacts as evidence
G3 Logistical–organizational	Planning; coping with uncertainty and risk (*Into action*)	Problem solving	Active experimentation	Operations/digital-twin practice and its fidelity progression
G4 Communicative–reflective	Working with others; learning through experience (*Into action*)	Communication and collaboration	Reflective observation	Trace-mediated reflection as an assessable act

Note. The mapping is not one-to-one: EntreComp has three areas, and G3 and G4 both draw on the *into action* area through different competences. DigComp and Kolb columns give the predominant, not exclusive, association; the four groups span the Kolb modes as a set but not in Kolb's canonical order.

Table 5 positions the framework against the nearest existing accounts. Competence frameworks and reviews specify competences or themes but not practices; tool-to-competence mappings work at the level of the tool; digital-twin-in-education studies supply environments without an entrepreneurial framing. The present framework is distinguished by taking the *practice* as its unit, grounding it in a specific vocational sector, tying each practice to an assessable artefact, and connecting practices to competences through explicit propositions.

Table 5
The framework contrasted with the nearest existing accounts.

Account	Unit of analysis	Sector grounding	What it does not provide
EntreComp [2]	Competences	None	Sector practice types; trace-based assessment
Reviews of digital entrepreneurship education [19, 60]	Research themes	None	A practice taxonomy or design model
Tool-to-competence mapping [23]	Tools	None	Practice-level grouping; the trace mechanism
Digital-twin-in-education [22, 34]	Technology	Manufacturing / eng.	Entrepreneurial framing; competence mapping
This framework	Practices	Automobile-transport VET	—

5.2. Propositions

The framework yields eight propositions (figure 5). Two are analytic, fixing the construct's boundary; six are empirical and, we argue, falsifiable by future study. The citations under each empirical proposition are *warrants* – works that make the prediction plausible – not tests of it; none tests the specific novel claim, which is the point of proposing it.

- **P1 (analytic).** An activity is a digital entrepreneurial practice only where the digital tool is subordinate to a modelled entrepreneurial action [23, 48, 55].
- **P2 (analytic).** The four groups partition the entrepreneurial-action space into distinct phases; this decomposition is definitional given the action-cycle frame (section 3.1), not an empirical discovery, and its outcome implications are carried by the empirical propositions below rather than by P2 itself [2, 49].
- **P3 (empirical).** Curricula that complete all four groups as a connected cycle produce greater competence gains than equal time spent on any subset – configuration, not exposure, matters [18, 54, 64].
- **P4 (empirical).** The *quality* of the digital-trace archive (its inspectability and the depth of reflection it records) predicts competence gains during training over and above time-on-task – distinct from P7, which concerns the *completeness* of the archive and *transfer* beyond training [27, 40, 52].
- **P5 (empirical).** Higher-fidelity environments (simulation, digital twins) amplify gains for G2 and G3 practices but add little to G1 and G4 [13, 29, 34, 37].
- **P6 (empirical).** Omitting G4 cannot be compensated by additional G1–G3 practice, because artefact-mediated reflection is not substitutable [30, 40, 52].
- **P7 (empirical).** Because a defined digital artefact is required for a practice to qualify (P1), the *assessability* of artefact-producing practice is definitional; the empirical claim is that the completeness of the artefact archive predicts *transfer* of competence to novel entrepreneurial tasks beyond the training context [26–28].
- **P8 (empirical).** Immersive and digital-twin practices develop rather than merely demonstrate competence only when embedded in a practice group and moderated by teacher digital-pedagogical competence [7, 8, 10, 56].

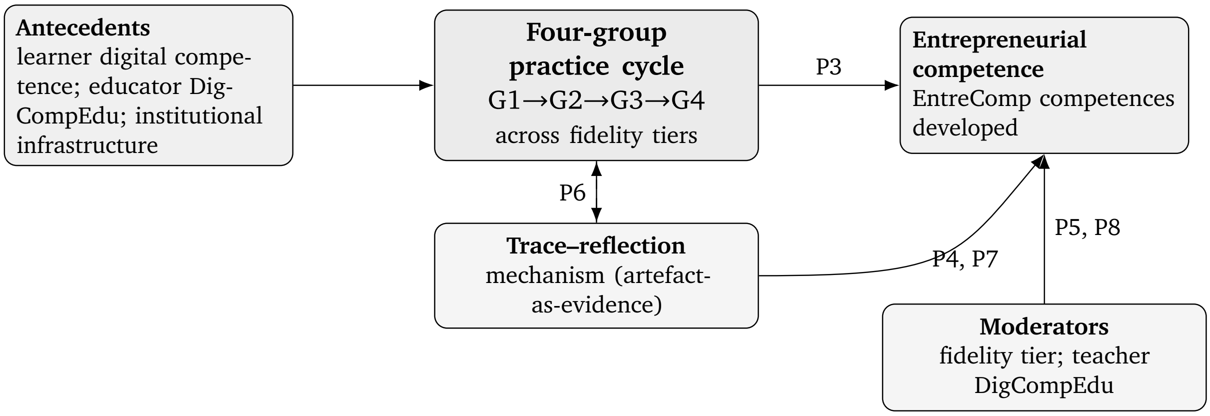

Figure 5: The framework as a logic model. Antecedents enable the four-group practice cycle, which develops entrepreneurial competence; the trace–reflection mechanism and the fidelity/educator moderators condition the effect. Arrows are labelled with the empirical propositions they represent (P3–P8); the analytic propositions P1–P2 are definitional and are not drawn as causal arrows.

5.3. A proposed assessment rubric

Because every practice yields an artefact, the framework supports criterion-referenced assessment. Table 6 proposes a rubric whose criteria name a group, its EntreComp thread, and the evidencing trace. Its four bands collapse EntreComp's eight-level progression to Foundation, Intermediate, Advanced, and Expert for tractability – a deliberate simplification, not a one-to-one correspondence – cross-walked to the SOLO taxonomy for the cognitive structure of the descriptors (unistructural to extended abstract) [2, 6]. The levels describe *competence*, which the design deliberately keeps on a separate axis from environment fidelity; where an Expert descriptor names a higher-fidelity resource (real users, a digital twin), it does so as an exemplary rather than a necessary form, and the level can in principle be reached at lower fidelity, so that a student's grade is not gated by their institution's resources. Two transversal criteria – cycle integration and justified tool selection – operationalise P3 and the "task over tool" principle respectively; because they depend on as-yet-untested propositions, they are design intentions pending validation. The rubric is a *proposed design artefact*: it has not been validated, and applying six criteria over a multi-artefact cycle for a full class implies a marking load that a real deployment must weigh. A validation programme would establish content validity through an expert panel with a content-validity index, scoring reliability through the evidence standards for rubrics [27], and an argument-based account tracing the scoring, generalisation, extrapolation, and use inferences [28].

5.4. Implications

For curriculum design, the framework recommends sequencing practices so that a cohort completes all four groups and, where resources allow, climbs the fidelity dimension across a programme. Crucially, the framework degrades gracefully: a complete G1–G4 cycle can be run entirely in the generic-tool tier with free, browser-based tools, and we take that low-fidelity cycle as the expected default rather than the exception. This matters for ordinary and under-resourced colleges, and for Ukrainian institutions operating under wartime disruption of power, connectivity, and scheduling, where the leftmost tier is the resilient core that keeps a full entrepreneurial-action cycle teachable and assessable offline or asynchronously. The digital-twin, immersive, and real-market tiers are opt-in extensions contingent on institutional resources or employer partnerships; they presuppose a level of teacher digital-pedagogical competence (DigCompEdu) that many transport-college instructors – often subject experts without formal digital-pedagogy training – have not yet acquired, so realising the higher tiers is as much a teacher-development task as a curriculum one. The real-market tier further raises supervision, liability, and data-handling questions – where student artefacts and client-interaction

Table 6
Proposed assessment rubric (design artefact, awaiting validation): criteria by competence thread and evidencing artefact, with EntreComp-progression levels.

Criterion (group; EntreComp thread)	Evidencing artefact	Level descriptors: Foundation → Intermediate → Advanced → Expert
Opportunity identification and value proposition (G1; ideas and opportunities)	Idea map; value-proposition / landing page	Names a need → states a value proposition → justifies it against client and market → differentiates and validates it (with users where available)
Technical–economic substantiation (G2; resources)	Cost / pricing / simulation model, with note	Lists cost items → computes cost and price → models a risk scenario → optimises across scenarios and defends the choice
Logistical–organizational planning and adaptation (G3; into action)	Route / schedule / adaptation artefact	Sequences steps → builds a feasible plan → adapts to a disruption → substantiates the plan against a model (a simulation or digital twin where available)
Digital communication, client orientation and reflection (G4; working with others; learning through experience)	Offer page / message / pitch / CRM trace; reflective note	Conveys information → addresses the client's need → persuades with evidence and reflects on the trace → manages feedback, self-evaluates against the trace, and revises
Cycle integration (transversal; operationalises P3)	The linked artefact chain across groups	Artefacts are separate → partially linked → coherent across the cycle → each artefact informs the next as one decision
Justified tool selection (transversal; "task over tool")	Rationale accompanying each artefact	Uses the given tool → chooses a suitable tool → justifies the choice by the task → selects and combines tools to fit the entrepreneurial action

traces are stored, and under what consent – that adopting institutions must resolve, typically through apprenticeship or employer arrangements. For pedagogy, the framework recommends assessing the artefact and the reasoning behind the tool choice rather than tool proficiency itself. For the sector, although the taxonomy is instantiated for automobile transport, its structure – an action cycle mapped to competences, evidenced by digital traces, and progressing along fidelity – is likely to transfer analytically to other asset-heavy, regulated, logistics-intensive vocational fields, a claim that itself invites testing.

6. Limitations

Several limitations bound these claims. First, the study is conceptual and design-oriented: the taxonomy, the propositions, and the rubric are derived from the literature and have not been validated with students or teachers, and no efficacy is claimed. Second, the four-fold structure is partly entailed by the analytic frame (EntreComp crossed with an action cycle) and by the authors' sensitising prior account; the synthesis therefore confirms and instantiates the groups more than it discovers them, and the contribution lies in the sector instantiation, the artefacts, and the propositions rather than in the number four. Third, the search could not access Scopus, Web of Science, or ERIC, and the Consensus engine was unavailable, so coverage is partial and the corpus is English- and Ukrainian-language only; consequently no new group emerged *in the searched corpus*, which is weaker than saturation, and at least one plausible candidate (regulatory-compliance practices, central to transport) was excluded on thin coverage and is flagged for future work rather than dismissed. Fourth, the evidence is uneven across groups: only the logistical–organizational group is strongly sector-grounded; the sector instantiation of the others rests partly on the authors' constructed illustrations (tables 1–3) pending validation, and the communicative–reflective group has *no* transport-specific study and, under a strict reading of the independence rule, only about two direct practice sources, so its warrant is chiefly structural. Fifth, the reliability statistic is limited: it was computed from two AI-generated coding passes (not independent human raters), so it indexes procedural consistency and cannot detect biases the passes share; it covers only group assignment (not screening, threshold, or tier coding), rests on 22 sources with only two in the weakest group, and is prevalence-sensitive given skewed marginals. Sixth, the practice-design space and rubric are analytic proposals: the fidelity tiers simplify a continuum, and the rubric's levels require empirical calibration. Finally, the differentia ("tool subordinate to action") is given an operational test but remains partly interpretive, and the "we are not aware of a prior taxonomy" claim is bounded to the sector and the databases searched. These limitations define the validation agenda rather than undermine the framework.

7. Conclusions

This study set out to replace a tool-centred account of digitalisation in automobile-transport vocational education with a practice-centred one. Through a PRISMA-ScR scoping review and best-fit framework synthesis, it distinguished four groups of digital entrepreneurial practice – project-based, technical–economic, logistical–organizational, and communicative–reflective – the first three each supported by at least three independent sources and the fourth by cycle completeness and corroborating scholarship, with a high procedural consistency of group assignment (Cohen's $\kappa = 0.94$). It argued that the four groups span a coherent cycle of entrepreneurial action – a structure partly entailed by the analytic frame – mapped them onto EntreComp and DigComp and onto experiential and activity-learning theory, and stated what those frameworks do not specify. Two conceptual moves turned the taxonomy into a framework: a trace–reflection mechanism that makes practices assessable through the digital artefacts they produce, and a practice-design space that positions each group against tiers of environment fidelity and treats immersive technology as a level of that dimension rather than a separate group. Eight propositions and a progression-anchored rubric translate the framework into testable and teachable form. The contribution is conceptual; its value now depends on empirical validation. Further work should implement the framework in automobile-transport colleges, test the propositions – especially the cycle-completeness (P3), trace-mediation (P4), and fidelity-moderation (P5) claims – and validate the rubric, and should examine whether the framework transfers to adjacent vocational sectors.

Author contributions

Conceptualization, O.O.L. and Ye.V.K.; methodology, O.O.L.; formal analysis, O.O.L. and Ye.V.K.; investigation, Ye.V.K.; writing – original draft preparation, O.O.L. and Ye.V.K.; writing – review and editing, O.O.L. Both authors have read and agreed to the published version of the manuscript.

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Data availability statement

The materials supporting this study – the a-priori protocol, the search log with the query record and PRISMA-ScR counts, and the coding matrix with the two independent AI coding passes and the procedural-consistency (κ) computation – are available from the authors on reasonable request. The study generated no primary human-participant data.

Conflicts of interest

The authors declare no conflict of interest.

Ethics approval

This study analysed published literature only and involved no human participants, no personal data, and no primary data collection; the learning cases presented are constructed illustrations. Ethical approval was therefore not required.

Declaration on Generative AI

The authors used AI-assisted tools during this study and disclose their use here. Large-language-model-based academic-search assistants and literature-retrieval interfaces (Semantic Scholar, Crossref, the Wiley Online Library, and PubMed) supported search planning, search-string refinement, and the verification of bibliographic metadata; the two independent coding passes were AI-generated (and are reported as a check on procedural consistency, not as human inter-rater reliability); and AI assistance supported the structural drafting and language editing of the manuscript. AI tools were not used to generate empirical data, to fabricate references or digital object identifiers, or to make the final decisions on source inclusion, coding, or interpretation. Every cited source was verified against a resolvable identifier by the authors, the procedural-consistency statistic (Cohen's κ) was computed from the two recorded coding passes, and the authors take full responsibility for the content of the manuscript.

References

[1] Arksey, H. and O'Malley, L., 2005. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, 8(1), pp.19–32. Available from: https://doi.org/10.1080/1364557032000119616.

[2] Bacigalupo, M., Kampylis, P., Punie, Y. and Van den Brande, G., 2016. *EntreComp – The entrepreneurship competence framework*. (EUR 27939 EN). Luxembourg: Publications Office of the European Union. Available from: https://doi.org/10.2791/593884.

[3] Banha, F., Graça, A.R., Góis, B. and Banha, F.M., 2025. A critical analysis of the Portuguese Framework for entrepreneurship education considering the EntreComp competence framework. *Entrepreneurship Education*, 8(1), pp.1–28. Available from: https://doi.org/10.1007/s41959-025-00135-y.

[4] Berman, T., Stuckler, D., Schallmo, D. and Kraus, S., 2024. Drivers and success factors of digital entrepreneurship: A systematic literature review and future research agenda. *Journal of Small Business Management*, 62(5), pp.2453–2481. Available from: https://doi.org/10.1080/00472778.2023.2238791.

[5] Bernadó, E. and Bratzke, F., 2024. Revisiting EntreComp through a systematic literature review of entrepreneurial competences. Implications for entrepreneurship education and future research. *The International Journal of Management Education*, 22(3), p.101010. Available from: https://doi.org/10.1016/j.ijme.2024.101010.

[6] Biggs, J.B. and Collis, K.F., 1982. *Evaluating the Quality of Learning: The SOLO Taxonomy (Structure of the Observed Learning Outcome)*. New York: Academic Press. Available from: https://doi.org/10.1016/C2013-0-10375-3.

[7] Blachly, B.D., Pitcher, B.D., White, J.C. and Behrend, T.S., 2025. Forging Technical Career Skills in Virtual Reality: How Immersion Shapes Learning and Engagement. *International Journal of Training and Development*, 30(2), pp.192–201. Available from: https://doi.org/10.1111/ijtd.70017.

[8] Bower, M. and Jong, M.S.Y., 2020. Immersive virtual reality in education. *British Journal of Educational Technology*, 51(6), pp.1981–1990. Available from: https://doi.org/10.1111/bjet.13038.

[9] Bubniak, Y., 2026. Features of the implementation of digital technologies in the training of future professional junior bachelors in automobile transport. Available from: https://doi.org/10.5281/zenodo.18420096.

[10] Caena, F. and Redecker, C., 2019. Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigCompEdu). *European Journal of Education*, 54(3), pp.356–369. Available from: https://doi.org/10.1111/ejed.12345.

[11] Carroll, C., Booth, A. and Cooper, K., 2011. A worked example of "best fit" framework synthesis: A systematic review of views concerning the taking of some potential chemopreventive agents. *BMC Medical Research Methodology*, 11(1), p.29. Available from: https://doi.org/10.1186/1471-2288-11-29.

[12] Carroll, C., Booth, A., Leaviss, J. and Rick, J., 2013. "Best fit" framework synthesis: refining the method. *BMC Medical Research Methodology*, 13(1), p.37. Available from: https://doi.org/10.1186/1471-2288-13-37.

[13] Chang, Y.S., 2021. Effects of virtual reality application on skill learning for optical-fibre fusion splicing. *British Journal of Educational Technology*, 52(6), pp.2209–2226. Available from: https://doi.org/10.1111/bjet.13118.

[14] Chervona, L., Bulvinska, O. and Lakusha, N., 2026. Development of student entrepreneurship: analysis of practices in Ukrainian universities. *Continuing Professional Education: Theory and Practice*, 86(1), pp.51–63. Available from: https://doi.org/10.28925/2412-0774.2026.1.4.

[15] Cohen, J., 1960. A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement*, 20(1), pp.37–46. Available from: https://doi.org/10.1177/001316446002000104.

[16] Elia, G., Margherita, A. and Passiante, G., 2020. Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process. *Technological Forecasting and Social Change*, 150, p.119791. Available from: https://doi.org/10.1016/j.techfore.2019.119791.

[17] Engeström, Y., 2001. Expansive Learning at Work: Toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14(1), pp.133–156. Available from: https://doi.org/10.1080/13639080020028747.

[18] Fayolle, A. and Gailly, B., 2015. The Impact of Entrepreneurship Education on Entrepreneurial Attitudes and Intention: Hysteresis and Persistence. *Journal of Small Business Management*, 53(1), pp.75–93. Available from: https://doi.org/10.1111/jsbm.12065.

[19] Fourqoniah, F., Aransyah, M.F. and Riani, L.P., 2025. Thematic Synthesis and Future Outlook in Digital Entrepreneurial Education. *Electronic Journal of e-Learning*, 23(3), pp.30–44. Available from: https://doi.org/10.34190/ejel.23.3.3910.

[20] Fox, J., Pittaway, L. and Uzuegbunam, I., 2018. Simulations in Entrepreneurship Education: Serious Games and Learning Through Play. *Entrepreneurship Education and Pedagogy*, 1(1), pp.61–89. Available from: https://doi.org/10.1177/2515127417737285.

[21] Gekara, V.O., Snell, D., Chhetri, P. and Manzoni, A., 2014. Meeting skills needs in a market-based training system: a study of employer perceptions and responses to training challenges in the Australian transport and logistics industry. *Journal of Vocational Education & Training*, 66(4), pp.491–505. Available from: https://doi.org/10.1080/13636820.2014.943800.

[22] Grieves, M., 2024. Digital Twins and Their Role in Reengineering Engineering Education. In: S. Sabri, K. Alexandridis and N. Lee, eds. *Digital Twin: Fundamentals and Applications*.

Cham: Springer Nature Switzerland, pp.237–261. Available from: https://doi.org/10.1007/978-3-031-67778-6_11.

[23] Hammoda, B., 2022. Mapping digital technologies used in entrepreneurship education against the competences they develop using EntreComp framework as a reference: A systematic literature review. *INTED2022 Proceedings*. IATED, 16th International Technology, Education and Development Conference, pp.5489–5498. Available from: https://doi.org/10.21125/inted.2022.1415.

[24] Huang, M., Xu, S., Guo, T., Ni, Y. and Xu, Y., 2024. Impact of Entrepreneurship Education on the Entrepreneurial Intention of Higher Vocational Students: A Moderated Mediation Effects Model. *European Journal of Education*, 59(4), p.e12775. Available from: https://doi.org/10.1111/ejed.12775.

[25] Irfan, M.S., Dasgupta, S. and Rahman, M., 2024. Toward Transportation Digital Twin Systems for Traffic Safety and Mobility: A Review. *IEEE Internet of Things Journal*, 11(14), pp.24581–24603. Available from: https://doi.org/10.1109/JIOT.2024.3395186.

[26] Isabelle, D.A., 2020. Gamification of Entrepreneurship Education. *Decision Sciences Journal of Innovative Education*, 18(2), pp.203–223. Available from: https://doi.org/10.1111/dsji.12203.

[27] Jonsson, A. and Svingby, G., 2007. The use of scoring rubrics: Reliability, validity and educational consequences. *Educational Research Review*, 2(2), pp.130–144. Available from: https://doi.org/10.1016/j.edurev.2007.05.002.

[28] Kane, M.T., 2013. Validating the Interpretations and Uses of Test Scores. *Journal of Educational Measurement*, 50(1), pp.1–73. Available from: https://doi.org/10.1111/jedm.12000.

[29] Kim, K.G., Oertel, C., Dobricki, M., Olsen, J.K., Coppi, A.E., Cattaneo, A. and Dillenbourg, P., 2020. Using immersive virtual reality to support designing skills in vocational education. *British Journal of Educational Technology*, 51(6), pp.2199–2213. Available from: https://doi.org/10.1111/bjet.13026.

[30] Kolb, A.Y. and Kolb, D.A., 2005. Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management Learning & Education*, 4(2), pp.193–212. Available from: https://doi.org/10.5465/amle.2005.17268566.

[31] Kolb, D.A., 1984. *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice-Hall.

[32] Kolho, P., 2024. A vocational education and training subject teacher for fostering students' entrepreneurial skills—The development of a conceptual model. *International Journal of Training and Development*, 28(4), pp.430–453. Available from: https://doi.org/10.1111/ijtd.12335.

[33] Kraus, S., Palmer, C., Kailer, N., Kallinger, F.L. and Spitzer, J., 2018. Digital entrepreneurship: A research agenda on new business models for the twenty-first century. *International Journal of Entrepreneurial Behavior & Research*, 25(2), pp.353–375. Available from: https://doi.org/10.1108/IJEBR-06-2018-0425.

[34] Kumar Karanam, S.A. and Hartman, N.W., 2025. A systematic review of Digital Twin (DT) and virtual learning environments (VLE) for smart manufacturing education. *Manufacturing Letters*, 44, pp.1597–1608. 53rd SME North American Manufacturing Research Conference (NAMRC 53). Available from: https://doi.org/10.1016/j.mfglet.2025.06.179.

[35] Kyrylenko, Y., 2024. Entrepreneurial competence of the future specialist: professional and personal dimensions. *Alfred Nobel University Journal of Pedagogy and Psychology*, 2(28), pp.164–172. Available from: https://doi.org/10.32342/3041-2196-2024-2-28-16.

[36] Lackéus, M., 2015. *Entrepreneurship in Education: What, Why, When, How*. (OECD Local Economic and Employment Development (LEED) Papers, 2015/06). Paris: OECD Publishing. Available from: https://doi.org/10.1787/cccac96a-en.

[37] Le, T.V. and Fan, R., 2024. Digital twins for logistics and supply chain systems: Literature review, conceptual framework, research potential, and practical challenges. *Computers & Industrial Engineering*, 187, p.109768. Available from: https://doi.org/10.1016/j.cie.2023.109768.

[38] Levac, D., Colquhoun, H. and O'Brien, K.K., 2010. Scoping studies: advancing the methodology.

Implementation Science, 5(1), p.69. Available from: https://doi.org/10.1186/1748-5908-5-69.

[39] Levytsky, V.O., Radynskyi, S.V. and Krupka, A.Y., 2024. Use of digital technologies in business: modern view and legal framework. Available from: https://doi.org/10.52058/2786-6300-2024-2(20)-73-87.

[40] Mawson, S., Casulli, L. and Simmons, E.L., 2023. A Competence Development Approach for Entrepreneurial Mindset in Entrepreneurship Education. *Entrepreneurship Education and Pedagogy*, 6(3), pp.481–501. Available from: https://doi.org/10.1177/25151274221143146.

[41] McHugh, M.L., 2012. Interrater reliability: the kappa statistic. *Biochemia Medica*, 22(3), pp.276–282. Available from: https://doi.org/10.11613/BM.2012.031.

[42] Mejía Dorantes, L. and Allen, H., 2024. A review of the future transport labour market: An EU approach. *European Transport Studies*, 1, p.100007. Available from: https://doi.org/10.1016/j.ets.2024.100007.

[43] Melnychenko, O., 2022. Development of entrepreneurial competence and its role in the reconstruction of Ukraine. *Educological Discourse*, 37(2), p.89–100. Available from: https://doi.org/10.28925/2312-5829.2022.26.

[44] Mishra, P. and Koehler, M.J., 2006. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, 108(6), pp.1017–1054. Available from: https://doi.org/10.1111/j.1467-9620.2006.00684.x.

[45] Morselli, D., 2019. *The Change Laboratory for Teacher Training in Entrepreneurship Education: A New Skills Agenda for Europe*, SpringerBriefs in Education. Cham: Springer. Available from: https://doi.org/10.1007/978-3-030-02571-7.

[46] Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A. and Aromataris, E., 2018. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, 18(1), p.143. Available from: https://doi.org/10.1186/s12874-018-0611-x.

[47] Nabi, G., Liñán, F., Fayolle, A., Krueger, N. and Walmsley, A., 2017. The Impact of Entrepreneurship Education in Higher Education: A Systematic Review and Research Agenda. *Academy of Management Learning & Education*, 16(2), pp.277–299. Available from: https://doi.org/10.5465/amle.2015.0026.

[48] Nambisan, S., 2017. Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship. *Entrepreneurship Theory and Practice*, 41(6), pp.1029–1055. Available from: https://doi.org/10.1111/etap.12254.

[49] Neck, H.M. and Greene, P.G., 2011. Entrepreneurship Education: Known Worlds and New Frontiers. *Journal of Small Business Management*, 49(1), pp.55–70. Available from: https://doi.org/10.1111/j.1540-627X.2010.00314.x.

[50] Pavlenko, O., Velykodnyi, D., Lavrentieva, O.O. and Filatov, S., 2020. The Procedures of Logistic Transport Systems Simulation into the Petri Nets Environment. In: O. Sokolov, G. Zholtkevych, V. Yakovyna, Y. Tarasich, V. Kharchenko, V. Kobets, O. Burov, S. Semerikov and H. Kravtsov, eds. *Proceedings of the 16th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume II: Workshops, Kharkiv, Ukraine, October 06-10, 2020*. CEUR-WS.org, *CEUR Workshop Proceedings*, vol. 2732, pp.854–868. Available from: https://doi.org/10.55056/ceur-ws.org/Vol-2732/20200854.pdf.

[51] Pavliuk, B.V. and Yashchuk, S.V., 2025. European methodologies for the digitalization of vocational education: Standards, instruments, and implementation practices. *Modern Information Technologies and Innovation Methodologies of Education in Professional Training Methodology Theory Experience Problems*, 78, p.118–130. Available from: https://doi.org/10.31652/2412-1142-2025-78-118-130.

[52] Pedrosa, D. and Morgado, L., 2024. Immersive Virtual Reality, Augmented Reality and Mixed Reality for Self-regulated Learning: A Review. In: D. Crawford, J. Foss, N. Lambert, M. Reed and J. Kriebel, eds. *Technology, Innovation, Entrepreneurship and Education*. Cham: Springer Nature Switzerland, *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, vol. 57, pp.64–81. Available from: https://doi.org/10.1007/

978-3-031-59383-3_5.
[53] Pittaway, L. and Cope, J., 2007. Entrepreneurship Education: A Systematic Review of the Evidence. *International Small Business Journal*, 25(5), pp.479–510. Available from: https://doi.org/10.1177/0266242607080656.
[54] Pittaway, L. and Cope, J., 2007. Simulating Entrepreneurial Learning: Integrating Experiential and Collaborative Approaches to Learning. *Management Learning*, 38(2), pp.211–233. Available from: https://doi.org/10.1177/1350507607075776.
[55] Reckwitz, A., 2002. Toward a Theory of Social Practices: A Development in Culturalist Theorizing. *European Journal of Social Theory*, 5(2), pp.243–263. Available from: https://doi.org/10.1177/13684310222225432.
[56] Redecker, C., 2017. *European framework for the digital competence of educators – DigCompEdu*. (EUR 28775 EN). Luxembourg: Publications Office of the European Union. Available from: https://doi.org/10.2760/159770.
[57] RezaeiZadeh, M., Hogan, M., O'Reilly, J., Cunningham, J. and Murphy, E., 2017. Core entrepreneurial competencies and their interdependencies: insights from a study of Irish and Iranian entrepreneurs, university students and academics. *International Entrepreneurship and Management Journal*, 13(1), pp.35–73. Available from: https://doi.org/10.1007/s11365-016-0390-y.
[58] Rizal, Y., Sudira, P. and Mutohhari, F., 2022. Digital Entrepreneurship of Vocational Educations: Enthusiasm Level and Entrepreneurial Personality of Students. *Journal of Education Technology*, 6(4), pp.578–585. Available from: https://doi.org/10.23887/jet.v6i4.46297.
[59] Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., Burroughs, H. and Jinks, C., 2018. Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & Quantity*, 52(4), pp.1893–1907. Available from: https://doi.org/10.1007/s11135-017-0574-8.
[60] Sitaridis, I. and Kitsios, F., 2023. Digital entrepreneurship and entrepreneurship education: a review of the literature. *International Journal of Entrepreneurial Behavior & Research*, 30(2-3), pp.277–304. Available from: https://doi.org/10.1108/IJEBR-01-2023-0053.
[61] Toutain, O., Loi, M. and Opizzi, M., 2026. Entrepreneurial competencies in vocational education. *Entrepreneurship & Regional Development*, 38(3-4), pp.467–488. Available from: https://doi.org/10.1080/08985626.2025.2565242.
[62] Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D., Moher, D., Peters, M.D.J., Horsley, T., Weeks, L., Hempel, S., Akl, E.A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M.G., Garritty, C., Lewin, S., Godfrey, C.M., Macdonald, M.T., Langlois, E.V., Soares-Weiser, K., Moriarty, J., Clifford, T., Tunçalp, Ö. and Straus, S.E., 2018. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*, 169(7), pp.467–473. Available from: https://doi.org/10.7326/M18-0850.
[63] Vuorikari, R., Kluzer, S. and Punie, Y., 2022. *DigComp 2.2, The Digital Competence framework for citizens – With new examples of knowledge, skills and attitudes*. (EUR 31006 EN). Luxembourg: Publications Office of the European Union. Available from: https://doi.org/10.2760/115376.
[64] Wiyono, B.B., Imron, A., Sumarsono, R.B., Musa, K. and Saat, R.B.M., 2025. The effect of constructivist learning and project-based learning model on students' entrepreneurial competence in higher education. *Cogent Education*, 12(1), p.2557606. Available from: https://doi.org/10.1080/2331186X.2025.2557606.
[65] Zdolsek Draksler, T. and Sirec, K., 2021. The Study of Entrepreneurial Intentions and Entrepreneurial Competencies of Business vs. Non-Business Students. *Journal of Competitiveness*, 13(2), pp.171–188. Available from: https://doi.org/10.7441/joc.2021.02.10.
[66] Zhong, M. and Zhou, Y., 2024. Virtual-reality system for elevator maintenance education: Design, implementation and evaluation. *Engineering Reports*, 6(6), p.e12873. Available from: https://doi.org/10.1002/eng2.12873.