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COMMENTARY

When Teaching Factories Meet Project-Based Learning: Rethinking Evidence of Impact on Students' Soft Skills and Entrepreneurial Intention

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Abstract

This commentary examines Hulyadi et al. (2025), which reports that a project-based teaching factory (PbTF) model in a chemical cleaning industry context improved students' soft skills and entrepreneurial intention over a short intervention. The article's key contribution is practical: it operationalizes "teaching factory" as a sequenced learning design with validated tools and measurable outcomes. However, the strength of causal claims is limited by the one-group pretest–posttest design, a small cohort, and outcomes closely aligned with course activities. The observed gains may reflect increased opportunities to collaborate, assessment familiarity, or short-term motivational uplift rather than durable competence and entrepreneurial behavior. This commentary offers a cautious reading of the evidence, proposes alternative interpretations consistent with the reported data, and suggests evaluation steps that would clarify mechanisms, durability, and generalizability. PbTF-PjBL appears promising as an applied learning package, but stronger comparative and longitudinal evidence is needed before treating it as a robust impact model.

Keywords: Teaching factory; Project-based learning; Soft skills; Entrepreneurial intention; Chemical cleaning education

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INTRODUCTION

Across many higher education systems, entrepreneurship programs are expected to do more than transmit concepts: they are expected to cultivate employability-relevant soft skills and foster sustainable entrepreneurship. Yet evidence from developing economies suggests that low entrepreneurial interest among graduates contributes to unemployment pressures (Shahriar et al., 2024), while large-scale European findings indicate that entrepreneurship education does not always translate into entrepreneurship outcomes (Lechuga-Sancho et al., 2022). Qualitative work has also shown that program implementation can be weak, including limited pedagogical innovation and a persistent focus on academic achievement rather than industry and business capability (Samsuri et al., 2023; Bhakti et al., 2022). Even where entrepreneurship education is mandated, intention can remain low when learning experiences do not provide credible opportunities to practice entrepreneurial behavior (Setyawati et al., 2021).

One reason these efforts underdeliver is that entrepreneurship capability is partly mediated by human factors such as creativity, communication, leadership, and self-efficacy, which are difficult to build through traditional lecture-dominant instruction (Sanda, 2024; Kumar & Shukla, 2022). Empirical and scientometric work supports the association between soft skills and entrepreneurship-related outcomes (Machali et al., 2021; Škare et al., 2022), but also suggests that these competencies do not develop optimally without purposeful, innovative learning designs (Kakouris, 2021; Xu, 2022).

The Teaching Factory (TEFA) is often positioned as a best-practice response for Industry 4.0-era competency development because it aligns academic learning with industrial workflows and constraints (Mourtzis et al., 2023; Weyand et al., 2023). TEFA has been developed in phased life-cycle terms and networked models, emphasizing structured implementation and authentic production-like experiences (Tisch et al., 2019; Mavrikios et al., 2019). To deepen soft-skill development, scholars have recommended integrating TEFA with project-based learning (Szabó et al., 2024), since PjBL is linked to higher-order thinking, motivation, and collaborative inquiry when well designed (Barak & Dori, 2005; Sasson et al., 2018; Wu & Wu, 2020). Against this backdrop, Hulyadi et al. (2025) propose PbTF in chemical cleaning, a domain with authentic service demand and safety-compliance constraints that may make teamwork, risk management, and decision-making visible and assessable (Lucila-Giammatteo & Obaya Valdivia, 2021; Mattila et al., 2020).

COMMENTARY ON THE FOCAL ARTICLE

Hulyadi et al. (2025) present PbTF as a seven-phase learning model (orientation through iteration/scale-up) implemented over multiple weeks in a laboratory "pilot plant" setting. Conceptually, the article fits within the TEFA tradition that seeks to bridge academic instruction and industrial practice by simulating production or service workflows, with sequencing that resembles established learning-factory life-cycle thinking (Tisch et al., 2019; Chryssolouris et al., 2016). This matters because TEFA discussions often remain generic, whereas implementation requires explicit phases, deliverables, and quality gates. The study's account of cross-phase supports (knowledge flow, soft-skills workshops, entrepreneurship clinic) also aligns with the idea that learning factories are ecosystems, not single activities (Mavrikios et al., 2019; Jing et al., 2023).

The chemical cleaning context is not a cosmetic choice. Cleaning involves chemical selection, risk mitigation, and waste considerations, and it sits at the interface of technical performance and user constraints. That domain specificity makes "authenticity" plausible, especially given evidence that cleaning and chemical processes can be meaningfully taught through context-based approaches (Lucila-Giammatteo & Obaya Valdivia, 2021) and that cleaning practices carry measurable performance and safety implications (Ang et al., 2011; Mattila et al., 2020). If PbTF requires teams to design formulations and document safety/waste

procedures, then communication, coordination, and problem solving can become observable behaviors rather than abstract targets.

Methodologically, the article reports expert validation (content and construct) and a pilot effectiveness test using a one-group pretest–posttest design. The validation step is valuable, because TEFA implementations are often heterogeneous and under-specified; expert review provides an initial filter for coherence, relevance, and sequencing logic (Indriaturrahmi et al., 2024). For outcomes, the authors use an observation-based soft-skills instrument and an entrepreneurial intention questionnaire. Observation is defensible for soft skills because these competencies are enacted in interaction; however, measurement research reminds us that soft skills require careful psychometrics and rater calibration to avoid conflating visibility with competence (Escolà-Gascón & Gallifa, 2022; Fantozzi et al., 2024). For entrepreneurial intention, the use of an existing questionnaire family is appropriate, especially because entrepreneurial intention is frequently treated as an intermediary construct that can respond to educational experiences even when behavior change is harder to capture (Heredia-Carroza et al., 2024; Eesley & Lee, 2021).

The reported pre–post gains are large and consistent across subdimensions. Within a pilot logic, these results can reasonably be read as evidence that students performed better on targeted indicators after experiencing PbTF (Hulyadi et al., 2025). Still, a more careful reading is that the article demonstrates feasibility and promise rather than settled causal impact. That interpretation is consistent with the broader literature showing that entrepreneurship education outcomes are mixed and highly sensitive to pedagogy, ecosystem supports, and industry linkage strength (Lechuga-Sancho et al., 2022; Maritz et al., 2022). A final point worth noting is conceptual: PbTF, as described, implicitly depends on structured reflection at quality gates and debrief points. This connects to findings from another recent Social Sciences & Humanities Open article showing that emphasizing reflective processes in inquiry can strengthen preservice teachers' critical thinking, suggesting that reflection may be one plausible mechanism for competence growth in applied project environments (Prayogi et al., 2025; Sasson et al., 2018).

CRITICAL APPRAISAL AND ALTERNATIVE INTERPRETATIONS

The most important limitation is causal ambiguity. A one-group pretest–posttest design cannot distinguish intervention effects from maturation, testing effects, or expectancy effects, even when statistical significance and large effect sizes are reported (Creswell & Creswell, 2018; Cohen, 2013). In PbTF specifically, improvement could arise simply because students get repeated opportunities to collaborate under deadlines and because instructors and rubrics make expectations clearer across weeks. That is, the design may intensify practice and feedback loops, which would predict improvement in performance even without uniquely "TEFA" ingredients (Chang et al., 2018; Wu & Wu, 2020).

A second alternative interpretation concerns what exactly "soft skills" scores represent. In project-based settings, observable behaviors increase because the

learning design forces interaction (team planning, division of labor, presentations, peer negotiation). Ratings may therefore capture "interaction density" rather than transferable skill (Usher & Barak, 2018; Marks & Richards, 2012). Without strong inter-rater evidence reported in the focal article and without triangulation (peer ratings, artifact-based evidence, performance tasks in novel contexts), the most defensible claim is improved soft-skill performance *within the PbTF environment* (Escolà-Gascón & Gallifa, 2022; Fantozzi et al., 2024). The observed reductions in dispersion at posttest could also reflect tighter rubric alignment or converging rater expectations over time, not only student convergence.

Third, entrepreneurial intention is an important but proximal outcome. Intention can rise after salient educational experiences, especially when students' perceived feasibility and self-efficacy shift, yet intention does not necessarily convert to business creation (Lechuga-Sancho et al., 2022; Dewantoro et al., 2020). Mixed evidence on whether university entrepreneurship programs promote entrepreneurship supports a cautious stance here (Eesley & Lee, 2021). A plausible alternative interpretation is that PbTF primarily increases perceived relevance and confidence ("I can do this") because students complete a tangible product dossier, cost sheet, or venture concept, which can elevate self-perception and motivation even if long-term entrepreneurial behavior remains unchanged (Kumar & Shukla, 2022; S.-Y. Wang et al., 2021).

Fourth, mechanism attribution remains unclear because PbTF bundles multiple active ingredients: TEFA authenticity, PjBL structure, mentoring, assessment gates, and entrepreneurship clinics. PjBL alone can improve higher-order thinking and collaborative skills when projects involve open inquiry and ill-structured problems (Barak & Dori, 2005; Pecore, 2015). TEFA literature argues that production-like constraints and process realism are the value add (Mourtzis et al., 2023; Weyand et al., 2023). Without comparison conditions such as "PjBL without TEFA constraints" or "TEFA without extended PjBL inquiry," the study cannot specify which ingredient drives changes (Reining & Kauffeld, 2022; Szabó et al., 2024).

Finally, the novelty claim is credible at the domain level, but its generalizability is bounded. Chemical cleaning has specific safety, waste, and compliance characteristics that may amplify observable teamwork and risk communication (Lovén et al., 2019; Shin et al., 2013). Replication in other service or manufacturing contexts, ideally across sites and cohorts, is needed to test whether PbTF effects depend on domain constraints or whether the model transfers broadly (Tisch et al., 2019; Jing et al., 2023). In short, the paper is best read as a strong feasibility demonstration with promising signals, not as definitive evidence of impact.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Future studies should introduce comparison conditions to separate the contribution of teaching-factory authenticity from project-based learning scaffolding and from instructor feedback effects. A feasible design is a quasi-experiment with intact classes: PbTF versus PjBL-only versus conventional instruction, with the same assessment timeline. Outcomes should be broadened

beyond single-course ratings by adding peer assessment, artifact-based scoring (project logs, safety plans, cost sheets), and transfer tasks that require students to perform teamwork and problem solving in a new scenario. Entrepreneurial outcomes should move beyond intention to observable behaviors such as opportunity identification quality, pitching performance, customer discovery activities, or participation in entrepreneurship initiatives. Durability should be tested through delayed posttests and follow-up during internships or capstone projects.

For practice, the immediate actionable lesson is design discipline: projects need explicit roles, accountability, and structured decision points where teams must justify choices under constraints. If institutions cannot replicate full teaching-factory conditions, they can still borrow the logic of staged deliverables, risk and quality checkpoints, and iterative improvement cycles, since these features likely drive much of the learning value.

CONCLUSION

Hulyadi et al. (2025) offer a clear, implementable PbTF blueprint for chemical cleaning education and report large pre–post improvements in soft skills and entrepreneurial intention. The paper's strongest contribution is practical and developmental: it translates TEFA and PjBL into a sequenced model with defined supports and assessable outputs. The main limitation is interpretive: the pilot design cannot isolate PbTF as the cause of gains, and the outcomes may reflect context-bound performance and short-term motivational uplift rather than durable competence and entrepreneurial behavior. Several alternative explanations remain consistent with the evidence, including increased interaction opportunities, rubric alignment effects, and general project practice. A more decisive evidence base will require comparative designs, triangulated measurement, and longitudinal follow-up. Until then, PbTF-PjBL should be treated as a promising approach worth refining and replicating, rather than as a settled impact model.

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