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Production-Embedded Curriculum Enactment and Meaning-Making in Teaching Factory: An Interpretive Case Study of Shrimp Aquaculture Vocational Education in Indonesia

Dani Darmawan[1], Dedy Achmad Kurniady[2], Aan Komariah[3], Taufani C Kurniatun[4]
[1]Universitas Pendidikan Indonesia, Indonesia
[2]Universitas Pendidikan Indonesia, Indonesia
[3]Universitas Pendidikan Indonesia, Indonesia
[4]Universitas Pendidikan Indonesia, Indonesia

ABSTRACT

Background. Teaching Factory has been widely promoted as a strategy for strengthening school–industry linkages in vocational education, yet it is often understood primarily through competency alignment and procedural replication. In production-intensive sectors such as shrimp aquaculture, curriculum relevance depends not only on formal alignment but also on learners' participation in real production systems shaped by technological standards, biological cycles, quality regimes, contractual arrangements, and market timing.

Purpose. This study examines how Teaching Factory functions as a production-embedded mechanism of curriculum enactment in an Indonesian vocational secondary school located within a shrimp aquaculture ecosystem.

Method. An interpretive qualitative case study design was employed. Data were collected through semi-structured interviews, direct observations, and institutional document analysis conducted across one complete shrimp cultivation cycle.

Results. The findings show that the Teaching Factory operates as an embedded production and economic unit rather than a simulated workshop. Curriculum standards are enacted through full-cycle shrimp cultivation, distributed school–industry roles, technological upgrading, contractual harvesting arrangements, and market-based quality requirements. Curriculum relevance is therefore produced through operational embeddedness rather than formal alignment alone.

Conclusion. By conceptualizing Teaching Factory as a mediating infrastructure between curriculum policy, industry governance, technological practice, and regional commodity production, this study contributes to vocational curriculum scholarship and offers a context-sensitive account of curriculum relevance in production-intensive TVET settings.

KEYWORDS

Curriculum Enactment, Production-Based Learning, Shrimp Aquaculture, Teaching Factory, Vocational Education

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Correspondence:
Dedy Achmad,
Dedy_achmad@upi.edu

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INTRODUCTION

Vocational curriculum is increasingly expected to move beyond the formal specification of occupational competencies toward meaningful enactment within authentic work and production settings. In technical and vocational education and training (TVET), this distinction is important because curriculum relevance is often claimed through industry alignment but realized through learners'

participation in the material, institutional, social, and economic conditions that organize work (Billett, 2011; Priestley et al., 2015). Recent international scholarship on work-integrated learning further emphasizes that workplace-based curriculum should be understood as an intentional educational design involving students, educational institutions, and external stakeholders, in which authentic work tasks mediate the integration of disciplinary knowledge, professional practice, and employability development (Ferns et al., 2025; Zegwaard et al., 2023). This perspective suggests that vocational relevance cannot be evaluated only by asking whether curriculum documents correspond to industry needs; it must also be examined through the ways curriculum is enacted in situated work systems.

Previous Teaching Factory studies have generally concluded that the model can narrow the gap between school-based learning and industry expectations by strengthening competency mapping, improving practical learning patterns, increasing student work readiness, and encouraging collaboration between vocational schools and business or industry partners. This emphasis is consistent with wider vocational education discussions on school–industry alignment and industry collaboration, which identify labour-market responsiveness and partnership quality as central concerns in TVET reform (Mahmudah & Santosa, 2021; Omar & Kamaruzaman, 2024). Empirical and review-based studies have identified infrastructure readiness, teacher expertise, management support, partnership quality, financial resources, and learning patterns as major determinants of effective Teaching Factory implementation (Wahjusaputri & Bunyamin, 2022; Dwijayanthi & Rijanto, 2022; Rifai et al., 2026). These studies have made an important contribution by showing that Teaching Factory can provide students with more authentic, industry-oriented experiences than conventional classroom instruction. However, they often treat curriculum relevance mainly as a problem of competency alignment, work-readiness outcomes, or procedural replication of industrial practice.

The limitation of this competency-based perspective is that it explains whether vocational curricula correspond to occupational standards, but it does not sufficiently explain how those curricula become meaningful within the changing conditions of real production. Competency alignment tends to privilege curriculum documents, training modules, assessment indicators, and lists of industry-required skills, while giving less attention to the situated processes through which knowledge, judgement, coordination, and accountability are formed in actual work. This limitation is also reflected in broader debates on vocational knowledge, which warn that reducing vocational education to immediately observable skills can weaken students' access to systematic knowledge and occupational judgement (Wheelahan, 2010; Wheelahan, 2015). International research on curriculum enactment and workplace pedagogy suggests that curriculum is not simply delivered or implemented; it is interpreted, mediated, and reconstructed through institutional arrangements, actor agency, tools, routines, and workplace participation (Ball et al., 2012; Billett, 2020; Lynch et al., 2023; Raelin, 2008). From this standpoint, Teaching Factory should be examined not only as a competency delivery model but also as a curriculum enactment mechanism situated within the material, temporal, technological, and economic organization of production.

Several theoretical dimensions have therefore remained underdeveloped in the Teaching Factory literature. First, the temporal dimension of curriculum enactment can be strengthened through Billett's theory of vocational curriculum, which distinguishes between intended, enacted, and experienced curriculum and emphasizes that vocational learning is shaped by participation in authentic occupational practices (Billett, 2011). In production-based learning, this means that curriculum temporality is not determined solely by school calendars but also by the rhythm of work and production cycles. Second, the governance dimension can be explained through policy enactment

theory, which argues that educational policy and curriculum are not simply implemented but interpreted, translated, and enacted by actors within specific material and institutional contexts (Ball et al., 2012). This perspective helps explain how school leaders, teachers, industry partners, technical standards, and market actors jointly shape what students learn and when they learn it. Third, workplace pedagogy theory emphasizes that learning at work occurs through guided participation, access to workplace affordances, tools, routines, and social relations rather than through practical exposure alone (Billett, 2020). Fourth, the economic embeddedness of vocational learning can be understood through the concept of embeddedness, which explains that economic action is structured by social relations and institutional arrangements (Granovetter, 1985). Taken together, these theoretical perspectives indicate the need to extend Teaching Factory analysis beyond alignment and employability toward the study of production-embedded curriculum enactment.

Production-intensive aquaculture provides a distinctive context for advancing this discussion because curriculum enactment occurs inside a living, technologically mediated, and market-sensitive production system. Shrimp aquaculture is shaped by biological growth cycles, water quality dynamics, biosecurity risks, feed conversion, technological upgrading, buyer requirements, harvest timing, and quality classification. These dynamics also connect the school-based production unit to wider value-chain and production-network arrangements in which standards, suppliers, buyers, and governance relations influence local production practices (Coe & Yeung, 2015; Gereffi et al., 2005). Recent aquaculture scholarship and technical training initiatives emphasize that sustainable aquaculture development depends on updated practical skills, private-sector value-chain linkages, biosecurity knowledge, technology adoption, and coordinated knowledge transfer (Zornu et al., 2023; Xu, 2025; Paul et al., 2025). In such a context, vocational learning cannot be understood as simulated practice alone because students encounter curriculum through decisions that affect real production performance, economic accountability, and market acceptance. This makes shrimp aquaculture a theoretically productive site for examining how curriculum relevance is generated through operational embeddedness.

Based on this gap, this study asks: How does Teaching Factory function as a production-embedded mechanism of curriculum enactment within Indonesia's shrimp aquaculture-based vocational education?

The conceptual novelty of the study lies in articulating production-embedded curriculum enactment as a process through which formal curriculum becomes educationally meaningful inside an operating production ecosystem. The concept refers to the mediation of curriculum standards through real production cycles, distributed school–industry roles, technological systems, market-linked quality regimes, and economic accountability. It differs from competency alignment because it does not stop at matching skills with occupational requirements; it examines how competencies are interpreted, sequenced, practiced, evaluated, and made consequential within the temporal and organizational structure of production. Through this lens, Teaching Factory is conceptualized as a mediating infrastructure between curriculum policy, workplace pedagogy, industry governance, and regional commodity production. The study therefore contributes to vocational curriculum scholarship by explaining curriculum relevance as a situated achievement produced through sustained participation in local production rather than formal competency correspondence alone.

RESEARCH METHODOLOGY

Research Design

This study employed an interpretive qualitative case study design to examine how curriculum is enacted within a production-embedded vocational setting. The case was bounded by one shrimp

aquaculture-based Teaching Factory located in an Indonesian vocational secondary school and by one complete shrimp cultivation cycle observed during the fieldwork period. This design is appropriate for investigating a context-dependent phenomenon in depth and for explaining how educational practices are shaped by institutional, technical, and production settings (Creswell & Poth, 2024). Following qualitative reporting standards, the methodological description emphasizes the case boundary, data sources, fieldwork duration, interview procedures, observation scope, and analytic transparency so that readers can assess the credibility and transferability of the findings.

The case study focused on a shrimp aquaculture-based Teaching Factory in an Indonesian vocational secondary school, tracing how curriculum standards, industry expectations, production cycles, and market-linked governance converged in everyday practices. The interpretive orientation emphasized meaning-making, contextual explanation, and researcher reflexivity in understanding complex educational phenomena (Kajamaa et al., 2020).

Data Collection

Data were collected through semi-structured interviews, direct observations, and institutional document analysis during fieldwork conducted from July to December 2025, covering one complete shrimp cultivation cycle. Fourteen semi-structured interviews were conducted with school leaders, Teaching Factory coordinators, productive subject teachers, industry partners, technical personnel, and students directly involved in shrimp aquaculture production. Interviews were conducted at the school, Teaching Factory office, pond area, and partner-related field locations, depending on participant availability and the relevance of the topic being discussed. Each interview lasted approximately 35–75 minutes and focused on participants' roles, experiences, and interpretations of how curriculum standards were translated into production routines, how school and industry actors coordinated technical decisions, and how students participated in learning embedded in real aquaculture work. Semi-structured interviews were selected because they support focused inquiry while allowing flexibility to probe participants' situated experiences and emerging meanings (Husband, 2020). Direct observations were conducted repeatedly across the fieldwork period, with twelve observation sessions covering major cultivation stages. The researcher directly observed pond preparation, post-larvae stocking, feeding management, water quality monitoring, equipment maintenance, selected harvesting activities, sorting, and post-harvest handling when these activities occurred during scheduled field visits. Some complementary information, especially activities that occurred outside the researcher's presence or between observation visits, was obtained from participant reports, production records, and institutional documents. Thus, observation data were used primarily for activities directly witnessed by the researcher, while participant accounts and documents were used to contextualize and verify activities not directly observed. Institutional documents, including curriculum documents, Teaching Factory records, production notes, partnership documents, and relevant school reports, were reviewed to contextualize and triangulate interview and observation data. Together, these sources enabled the study to trace how curriculum enactment was embedded in the technical, organizational, and market-linked routines of shrimp aquaculture production.

Data Analysis

Data were analyzed through an iterative interpretive thematic procedure. Thematic analysis was used because it offers a flexible but systematic approach for identifying patterns of meaning across qualitative data and for linking empirical materials to conceptual interpretation (Kiger & Varpio, 2020; Naeem et al., 2023). Interview transcripts, observation notes, and institutional documents were

first organized chronologically and by data source. The researcher then read the materials repeatedly to become familiar with the data, noted preliminary impressions, and identified segments related to curriculum enactment, production routines, actor coordination, technological practices, and market-linked governance.

The coding process proceeded in four connected stages. First, raw data from interviews, field notes, and documents were segmented into meaningful units related to learning activities, production decisions, school–industry coordination, and student participation. Second, initial codes were assigned to these units, such as "pond preparation as learning sequence," "industry monitoring," "water quality decision-making," "harvest timing," "market-based quality classification," and "student participation in production routines." Third, related codes were grouped into broader themes, including production temporality, distributed actor roles, technological adaptation, market-linked coordination, and curriculum enactment through full-cycle production. Fourth, the themes were interpreted in relation to the research question and the conceptual focus on production-embedded curriculum enactment. Constant comparison across interviews, observations, and documents was used to identify convergence, divergence, and contextual variation. Analytical memos documented coding decisions, emerging themes, and interpretive links between raw data, codes, themes, and findings.

Table 1. Thematic Analysis Flow from Raw Data to Interpretation

Raw data	Interview transcripts, observation notes, curriculum documents, production records, partnership documents, and school reports.
Initial codes	Pond preparation as learning sequence; industry monitoring; water quality decision-making; student participation; harvest timing; market-based quality classification.
Themes	Production temporality; distributed actor roles; technological adaptation; market-linked coordination; curriculum enactment through full-cycle production.
Interpretation	Teaching Factory functions as a production-embedded mechanism through which curriculum standards become meaningful within real aquaculture production routines.

Trustworthiness and Rigor

Trustworthiness was enhanced through methodological triangulation across interviews, observations, and institutional documents. Credibility was supported by comparing interview accounts with observed production practices and relevant production records, while methodological coherence was maintained between the research question, data sources, analysis, and interpretation (Kajamaa et al., 2020).

Dependability and confirmability were supported through systematic field notes, coding records, analytical memos, and an audit trail linking raw data, codes, categories, and interpretations (Carcary, 2020). Reflexive awareness was maintained to acknowledge the researcher's interpretive position and ensure that findings remained grounded in the empirical materials.

RESULT AND DISCUSSION

Teaching Factory as an Embedded Production and Economic Unit

The Teaching Factory at SMK Perikanan dan Kelautan Puger operates within Jember's intensive vannamei shrimp aquaculture ecosystem. The school's Centre of Excellence status positions it at the intersection of national TVET reform and a local export-oriented aquaculture economy.

Unlike a simulated workshop, the Teaching Factory manages three intensive shrimp ponds two measuring 1,700 m² and one measuring 1,400 m² as an operational production unit. Each cultivation cycle lasts approximately three to four months, with operational costs ranging from IDR 250–450 million per cycle. Harvesting is organized through partial and total stages based on contractual arrangements specifying tonnage and size classifications.

The adoption of a two-step nursery pond system in early 2026 increased reported survival rates to 90–95%, indicating that production activities involve technological upgrading and commercially oriented aquaculture practices rather than demonstrative training alone.

The surrounding Puger coastal area reflects a shift from traditional polyculture toward intensive and semi-intensive vannamei shrimp farming shaped by technological innovation, export demand, and seafood supply-chain integration. Within this regional ecosystem, the Teaching Factory operates as part of an active production network rather than as an isolated school facility.

Its production operations involve feed suppliers, equipment providers, technical service actors, and market coordination, generating local economic circulation. The Teaching Factory therefore functions as an intermediary structure connecting curriculum policy, industry governance, and regional production dynamics.

Curriculum Enactment through Full-Cycle Production Practice

The Teaching Factory translates formal curriculum standards into full-cycle shrimp cultivation practice, making curriculum enactment part of an operational production system rather than a supplementary activity separated from classroom instruction. Classroom learning and pond-based production are sequenced through collaborative competency mapping between teachers and industry partners, including PT Haida Agriculture Indonesia for technical cultivation and PT Istana Cipta Sembada for marketing and quality standards. Through this coordination, formal competencies are distributed across actual production stages rather than confined to lesson plans, modules, or isolated practical exercises. Students therefore encounter the curriculum through pond preparation, post-larvae stocking, feed management, water quality monitoring, disease control, harvesting, sorting, and post-cycle evaluation. These activities require them to analyze water quality, calculate feed conversion ratios, observe growth and disease indicators, classify shrimp sizes according to market standards, and prepare basic production and financial reports, showing that curriculum objectives are operationalized through the technical routines and decision-making demands of shrimp aquaculture production.

Within this process, curriculum standards, industry expectations, technological systems, and market-based governance converge in the everyday organization of learning. Industry-defined quality requirements influence harvesting decisions, size classification, and post-harvest handling, while technological upgrading reshapes both production efficiency and the learning content experienced by students. As a result, curriculum enactment is synchronized with biological growth, market timing, and industry-defined quality expectations. Learning does not occur simply by applying pre-designed competencies to practice; rather, competencies are interpreted and made meaningful through participation in production rhythms, technical monitoring, contractual requirements, and market-oriented evaluation. In this sense, the Teaching Factory functions as a mechanism through which the curriculum becomes embedded in the standards and governance structures of production itself.

Distributed Roles in the Production–Learning System

Teaching Factory practices are sustained by distributed roles across school and industry actors, showing that the production–learning system depends on coordinated governance rather than on

classroom instruction alone. School leadership provides institutional support by facilitating partnerships, allocating resources, legitimizing production activities, and aligning the Teaching Factory with national vocational reform priorities. At the operational level, productive subject teachers and technical instructors mediate curriculum standards and production routines by translating formal competencies into pond-based tasks, monitoring student participation, and supervising technical procedures throughout the cultivation cycle. Four productive teachers and two technical instructors are involved in supervising pond preparation, feed management, water quality control, harvesting coordination, and post-cycle evaluation, combining instructional responsibilities with production supervision. Their role is therefore not limited to delivering subject content, but extends to organizing learning within the technical and temporal demands of shrimp aquaculture production.

Industry partners further shape the production–learning system through technical guidance, weekly monitoring, quality classification, marketing governance, and technological adaptation. PT Haida Agriculture Indonesia contributes to technical cultivation practices, while PT Istana Cipta Sembada connects production to quality and market requirements. Students participate in small groups across production stages and, for selected Grade 12 students, through internships aligned with industry standards, enabling them to experience how learning tasks are distributed across real production responsibilities. Together, these roles indicate that the Teaching Factory operates as a hybrid institutional arrangement in which educational objectives, production requirements, industry standards, and market coordination are collectively managed. The school therefore functions not merely as a provider of vocational instruction, but as an institutional actor embedded in a regional aquaculture production system.

Curriculum Relevance as Operational Embeddedness

The findings indicate that curriculum relevance is produced through operational embeddedness rather than formal alignment alone. Although curriculum standards and industry competencies are mapped collaboratively, their relevance becomes meaningful when students participate in full-cycle production governed by technical, biological, and market conditions. National vocational guidelines and the Indonesian National Work Competency Standards are translated into structured production tasks through teacher–industry collaboration, enabling students to encounter curriculum not only as prescribed competencies but also as operational requirements embedded in biological monitoring, feed management, water quality control, shrimp growth observation, quality classification, harvesting decisions, and basic production reporting. In this process, curriculum relevance is not simply a claim that school learning corresponds to industry expectations; it is experienced through participation in authentic work routines where competence is shaped by the demands of maintaining production quality, responding to biological variation, and meeting industry-defined standards.

Market-oriented governance further strengthens this form of relevance because harvest timing, shrimp size classification, tonnage decisions, and post-harvest handling are influenced by buyer agreements and contractual arrangements. These market-linked requirements expose students to the economic logics that structure aquaculture production and show how learning is connected to quality regimes, supply-chain expectations, and production accountability. Curriculum relevance is therefore lived, structured, and sustained within an authentic aquaculture ecosystem rather than located only in curriculum documents or competency maps. In this case, the Teaching Factory makes relevance visible as participation in production: students learn by engaging with the technical, organizational, biological, and market-based conditions that define shrimp aquaculture work, so relevance emerges from operational embeddedness rather than from correspondence with industry standards alone.

From Curriculum Alignment to Production-Embedded Relevance

The central contribution of this finding is that it changes how vocational curriculum relevance should be conceptualized in production-intensive industries. Rather than treating relevance as a static match between curriculum documents and occupational standards, the case shows that relevance is generated through students' participation in production systems where biological rhythms, technological standards, contractual governance, and market coordination shape what counts as competent performance. This changes the discussion from "Does the curriculum align with industry?" to "How does curriculum become educationally meaningful inside an operating production system?" In sectors such as aquaculture, agriculture, manufacturing, logistics, and other production-intensive industries, curriculum design should therefore begin not only from competency lists but also from the temporal sequence, risk structure, quality regime, technological infrastructure, and economic accountability of production. This finding extends international work-integrated learning debates, which emphasize authentic work-focused experiences as intentional curriculum components involving students, institutions, and external stakeholders (Ferns et al., 2025; Zegwaard et al., 2023).

What this finding changes is the position of competency-based education within vocational curriculum theory. Competency-based education remains useful for defining expected occupational performance, but it becomes inadequate when competencies are separated from the production conditions that give them meaning. In this case, competence was not simply demonstrated by completing tasks; it was formed through judgement under conditions of biological uncertainty, market timing, technology use, quality classification, and shared production responsibility. This challenges narrow competency-based models that reduce vocational curriculum to observable performance indicators and confirms wider critiques that vocational education must provide access to knowledge, judgement, and the social organization of practice, not merely task performance (Wheelahan, 2015; Billett, 2011). The study therefore advances the field by proposing production embeddedness as a missing curriculum principle: competencies should be designed, sequenced, assessed, and interpreted in relation to the production systems in which they are used.

Teaching Factory as a Mediating Infrastructure

The Teaching Factory also challenges existing curriculum models by showing that curriculum can function as a mediating infrastructure rather than only as a planned sequence of school-based learning outcomes. In conventional alignment models, industry usually appears as a source of standards, validation, internship placement, or labour-market feedback. In the production-embedded model observed here, industry becomes part of the curriculum's enactment environment: partners influence technical routines, quality standards, technological upgrading, harvesting arrangements, and market access. The Teaching Factory therefore changes the curriculum model from a school-centered design supported by industry to a distributed curriculum ecology in which school, industry, technology, commodities, and markets jointly organize learning. This contribution is important for international TVET debates because recent global reform agendas call for TVET systems that are more responsive to technological change, sustainability, labour-market transformation, and stakeholder governance (CEDEFOP, 2020; UNESCO, 2021; UNESCO-UNEVOC, 2024; World Bank et al., 2023).

This finding changes the interpretation of Teaching Factory from a practical learning strategy into a curriculum governance mechanism. It shows that the value of Teaching Factory is not simply that students practice in a realistic setting, but that curriculum, production standards, and market expectations are coordinated through an operational system. For vocational institutions, this implies that effective Teaching Factory design requires more than equipment procurement or industry visits.

It requires negotiated role distribution, shared technical supervision, data-informed production monitoring, clear quality standards, and mechanisms for connecting learning outcomes with production decisions. This argument resonates with research on industry–education integration and multi-actor vocational governance, which emphasizes that effective vocational learning depends on coordination among educational institutions, industry actors, and governance arrangements (Li et al., 2022; Wu & Sarker, 2022). In this sense, Teaching Factory contributes to curriculum theory by demonstrating how curriculum enactment gains structural depth when learning tasks are embedded in real economic and technological systems.

Governance, Temporality, and Distributed Agency

The findings further change how vocational curriculum temporality and agency should be understood. In production-intensive sectors, curriculum time cannot be organized only around semesters, lesson units, or assessment schedules. It must also respond to production phases, biological growth, risk events, technology cycles, and market windows. In shrimp aquaculture, the timing of stocking, feeding, monitoring, partial harvest, total harvest, and post-harvest handling structures when particular knowledge and skills become teachable. This means that vocational curriculum design should include production calendars as curriculum calendars. Agency is also distributed: teachers, students, industry technicians, school leaders, market actors, and production technologies jointly shape the learning process. This challenges school-centered models of curriculum implementation and aligns with curriculum enactment theory, which views curriculum as interpreted and mediated through actors, institutions, tools, and contexts (Ball et al., 2012; Lynch et al., 2023).

This changes the practical lesson for other vocational institutions. The case does not suggest that every school should replicate shrimp aquaculture production. Instead, it suggests that institutions located in strong regional production ecosystems can redesign curriculum around the real logic of those ecosystems. Other vocational institutions can learn four transferable principles from this case. First, curriculum mapping should include production processes, not only occupational standards. Second, assessment should evaluate students' judgement in authentic production decisions, not only task completion. Third, partnerships should be structured as shared curriculum governance arrangements, not only as internship or equipment support. Fourth, institutional capacity should be developed to manage production risks, quality standards, and ethical accountability. These principles move the discussion from "This finding supports previous studies" to "This finding changes what counts as curriculum relevance in production-intensive TVET."

Contextual Limits and Transferability

At the level of international TVET scholarship, the study contributes a shift from alignment-based relevance to enactment-based relevance. Alignment-based relevance asks whether curricula correspond to labour-market demand, while enactment-based relevance asks how learners participate in the systems through which occupational knowledge is produced, regulated, and valued. This distinction matters because global TVET policy increasingly emphasizes responsiveness to technological change, sustainability, and labour-market transformation, but responsiveness cannot be achieved through competency lists alone. Longstanding and contemporary TVET scholarship has similarly argued that vocational education should connect occupational preparation with democratic, social, and sustainable development purposes rather than reduce learning to narrow job training (Prosser & Allen, 1925; McGrath & Powell, 2016; Rauner & Maclean, 2008). Production-embedded curriculum enactment offers one way to theorize how TVET institutions can connect curriculum,

work, technology, and regional development without reducing education to immediate employer demand.

The findings should still be interpreted within the specific context of a coastal, commodity-based vocational institution embedded in intensive vannamei shrimp aquaculture. The contribution is therefore analytical rather than universally prescriptive. The level of production embeddedness observed in this case depends on regional commodity specialization, industry partnerships, operational production infrastructure, and institutional capacity. The study does not suggest that all vocational institutions can reproduce the same model; rather, it offers a transferable way of asking whether and how curriculum can be enacted through the production systems surrounding a vocational institution. This caution is consistent with qualitative case study logic, in which transferability depends on contextual similarity and analytical resonance rather than statistical generalization (Creswell & Poth, 2024), and it also aligns with international evidence that TVET system design must remain sensitive to institutional capacity, labour-market structure, and national skills-policy contexts (OECD, 2010; OECD, 2023).

Future research should therefore compare production-embedded curriculum enactment across sectors with different degrees of technological intensity, market exposure, ecological risk, and institutional capacity. Such comparison would clarify whether the concept applies only to aquaculture-based vocational education or whether it can also explain curriculum relevance in agriculture, fisheries, manufacturing, hospitality, logistics, renewable energy, and other production-intensive fields. The broader implication is that vocational curriculum theory should treat production systems not merely as external destinations for graduates but as active sites where curriculum is interpreted, organized, and made consequential.

CONCLUSION

This study asked how Teaching Factory functions as a production-embedded mechanism of curriculum enactment within Indonesia's shrimp aquaculture-based vocational education. The findings show that Teaching Factory performs this function by positioning curriculum inside a real production system rather than treating it as a set of competencies to be delivered through classroom instruction or simulated practice. In the case examined, curriculum standards were enacted through full-cycle shrimp cultivation, including pond preparation, stocking, feeding management, water quality monitoring, harvesting, quality classification, and basic production reporting. Teaching Factory therefore operates as a mediating infrastructure that connects formal curriculum, industry expectations, technological systems, production cycles, and market-based governance. Its curriculum function is not limited to strengthening school–industry linkage; it organizes learning through the operational rhythms and decision-making structures of aquaculture production, where students learn within conditions shaped by biological growth cycles, technological upgrading, contractual harvesting arrangements, and industry-defined quality standards.

The study concludes that curriculum relevance in this context is produced through operational embeddedness rather than formal alignment alone. Alignment with industry standards remains important, but it becomes meaningful only when translated into sustained participation in authentic production environments. By conceptualizing this process as production-embedded curriculum enactment, the study contributes to vocational curriculum scholarship by showing how relevance is structured through the interaction of curriculum policy, industry governance, technological practice, and regional commodity production. Although the findings are context-specific, they suggest that vocational institutions located within strong regional production ecosystems may move beyond peripheral industry collaboration toward deeper integration with local economic networks. Future

comparative research across sectors and regions is needed to examine whether production-embedded curriculum enactment also explains curriculum relevance in other commodity-based or technology-intensive vocational fields.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the authors used Copilot in order to improve paraphrasing and structural clarity. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; Submission
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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