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Students' Learning Needs as an Empirical Foundation for Project-Based Collaborative Learning Model Development toward SDG 4

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ABSTRACT

Objective: *To establish an empirical foundation for the development of a Project-Based Collaborative Learning (PjBCL) model by identifying undergraduate students' learning needs, interpreting their instructional significance, and translating the findings into empirical learner design requirements to support SDG 4 (Quality Education).* ***Method:*** *The study represents the needs assessment phase of a broader Educational Design Research (EDR) project. Following pilot testing of a preliminary 70-item questionnaire with 35 students, a refined instrument consisting of 49 substantive items, two attention-check items, and three open-ended questions was administered to 677 undergraduate students from 43 study programmes across nine faculties at Universitas Nusa Cendana, Indonesia. Quantitative data were analyzed using descriptive statistics, Cronbach's alpha, and exploratory factor analysis (EFA), while 2,031 qualitative response units were analyzed thematically. Both datasets were integrated through a joint display to derive empirical learner design requirements.* ***Results:*** *The findings revealed that local contextual relevance, collaboration and communication, and students' preference for Project-Based Collaborative Learning constitute strong readiness factors for instructional innovation. In contrast, problem-solving and creative-thinking competencies require further instructional support. Qualitative analysis generated six major themes, including authentic contextual learning, structured collaborative inquiry, higher-order cognition, learner agency, digital and information literacy, and instructional support. The integration of quantitative and qualitative findings produced a comprehensive set of learner design requirements for authentic local projects, structured collaboration, higher-order cognitive development, ethical digital learning, continuous instructional support, and learner autonomy.* ***Novelty:*** *Demonstrating a transparent evidence-to-design process by systematically integrating quantitative and qualitative findings to generate empirical learner design requirements. These evidence-based requirements provide a robust foundation for the subsequent design and development of an effective Project-Based Collaborative Learning (PjBCL) model.*

INTRODUCTION

Higher education is experiencing a profound transformation driven by rapid technological advancement, digitalisation, the expansion of the knowledge economy, and increasingly complex societal challenges. Contemporary universities are expected not only to transmit disciplinary knowledge but also to prepare graduates who can adapt to uncertain environments, collaborate across disciplinary boundaries, and generate innovative solutions to authentic problems (Beetham & Sharpe, 2019; Biggs et al., 2022; Darling-Hammond et al., 2020). This paradigm shift reflects a broader movement from teacher-centred instruction toward student-centred and competency-based learning, where learning success is measured not merely by content mastery but by students' ability to apply knowledge in complex real-world situations (Biggs et al., 2022; Daryanto & Karim, 2017). In response to these changes, international organisations and educational researchers consistently emphasise that higher education should cultivate higher-order competencies that enable graduates to remain competitive in rapidly evolving professional contexts (World Economic Forum, 2020). Among these competencies, problem-solving and creative-thinking skills have emerged as two of the most essential

learning outcomes because they support analytical reasoning, innovation, adaptability, and lifelong learning (Açıkgöz et al., 2022; Amabile, 2019; Beghetto & Corazza, 2019; English & Gainsburg, 2015). Furthermore, recent studies indicate that these competencies develop most effectively through learning environments that actively engage students in inquiry, collaboration, reflection, and authentic problem-solving rather than through passive knowledge transmission (Darling-Hammond et al., 2020; Guaman-Quintanilla et al., 2023). Consequently, the transformation of higher education requires instructional models that integrate meaningful learning experiences with the systematic development of higher-order competencies, thereby preparing graduates to address both global demands and context-specific challenges. These expectations are closely aligned with the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), which emphasises inclusive, equitable, and high-quality education that equips learners with the knowledge, skills, and competencies required to contribute to sustainable development. Accordingly, higher education institutions are increasingly expected to develop instructional innovations that prepare graduates not only for professional success but also for responsible participation in addressing complex sustainability challenges.

The increasing demand for higher-order competencies has encouraged universities to adopt instructional approaches that position students as active participants in the learning process rather than passive recipients of information. Grounded in constructivist learning theory, student-centred learning emphasises that knowledge is actively constructed through authentic experiences, social interaction, reflection, and meaningful engagement with real-world problems (Biggs et al., 2022; Darling-Hammond et al., 2020). In response, numerous instructional approaches have evolved to facilitate active learning, including inquiry-based learning, problem-based learning, project-based learning, and collaborative learning. Among these approaches, Project-Based Learning (PBL) has gained considerable attention because it enables students to investigate authentic problems, integrate interdisciplinary knowledge, and produce meaningful products through sustained inquiry and project implementation (Bell, 2010; Chen & Yang, 2019; Kokotsaki et al., 2016). Likewise, Collaborative Learning is widely recognised as an effective pedagogical approach for promoting communication, shared responsibility, knowledge co-construction, and collective problem-solving through structured interaction among learners (Davidson et al., 2014; Gillies, 2019; Laal & Ghodsi, 2012). Project-Based Learning (PjBL) has consistently been recognized as an effective student-centered approach that promotes deeper conceptual understanding, collaboration, and higher-order thinking skills (Chen & Yang, 2019; Krajcik & Shin, 2022). However, instructional innovations are often designed without systematically identifying learners' actual needs, whereas Educational Design Research emphasizes that needs assessment should serve as the empirical foundation for developing effective instructional interventions (McKenney & Reeves, 2018). Furthermore, successful implementation of PjBL depends not only on curriculum design but also on aligning instructional practices with learners' characteristics and contextual needs (Farrow et al., 2024). Recent studies further suggest that collaborative learning environments not only improve academic achievement but also strengthen students' behavioural, cognitive, and emotional engagement as well as collaborative participation in complex learning tasks (Gillies, 2019; Xu et al., 2024). Collectively, these findings indicate that Project-Based Learning and Collaborative Learning represent complementary instructional approaches capable of creating authentic, interactive, and learner-centred educational experiences that support the development of higher-order competencies in higher education. These

complementary characteristics indicate that integrating project-based learning and collaborative learning may provide a more comprehensive instructional approach than implementing either strategy independently. Such integration constitutes the conceptual basis for the development of the proposed PjBCL model.

Extensive empirical research has demonstrated the positive educational impact of Project-Based Learning and Collaborative Learning across various higher education contexts. Previous studies report that Project-Based Learning improves students' academic achievement, problem-solving ability, creativity, motivation, and engagement by providing authentic learning experiences that connect theoretical knowledge with practical application (Bell, 2010; Chen & Yang, 2019; Kokotsaki et al., 2016). Similarly, Collaborative Learning has also been shown to facilitate deeper conceptual understanding, communication skills, peer interaction, and collaborative experience through structured collaborative inquiry (Davidson et al., 2014; Gillies, 2019; Wang et al., 2023). More recently, several researchers have argued that integrating project-based and collaborative learning may generate greater educational benefits than implementing either approach independently because authentic projects naturally require sustained collaboration, shared decision-making, and collective problem-solving (Chen & Yang, 2019; Gillies, 2019).

Despite these promising findings, the current body of literature reveals several important gaps. First, most previous studies have primarily evaluated the effectiveness of Project-Based Learning or Collaborative Learning after instructional implementation, whereas relatively limited attention has been given to identifying students' learning needs prior to instructional design. Second, although Project-Based Learning and Collaborative Learning have been widely investigated, they are generally examined as separate instructional approaches rather than as integrated pedagogical components within a coherent instructional model. Third, only a limited number of studies have translated empirical evidence obtained from systematic needs assessments into explicit instructional design requirements that can guide evidence-informed model development within the EDR framework. Taken together, existing studies provide substantial evidence regarding instructional effectiveness but offer comparatively limited guidance regarding how instructional models should be systematically designed to address students' actual learning needs before implementation begins. These limitations establish a clear rationale for conducting the present study as the initial needs assessment phase of EDR aimed at formulating empirical learner design requirements that provide the evidence base for developing the PjBCL model.

Although substantial evidence supports the educational effectiveness of Project-Based Learning and Collaborative Learning, designing an instructional model requires more than selecting effective pedagogical approaches. Educational Design Research emphasises that instructional innovation should begin with a systematic analysis of educational problems, learner characteristics, contextual conditions, and instructional needs before design decisions are formulated (Akker et al., 2013; McKenney & Reeves, 2019; Plomp, 2013). Within this perspective, needs assessment serves as the empirical foundation for identifying design-relevant learning needs and translating them into explicit design requirements for the subsequent development and evaluation of the proposed PjBCL model. From this perspective, instructional models are expected to emerge not only from theoretical considerations but also from evidence generated by their intended users and learning contexts (McKenney & Reeves, 2019).

This perspective is particularly relevant for higher education institutions located in dryland and archipelagic regions, where graduates are expected to address authentic environmental, technological, and socio-economic challenges through contextual problem-solving and collaborative innovation. From an SDGs perspective, instructional models developed for such contexts should not only respond to local educational needs but also strengthen students' capacities to address environmental, socio-economic, and community challenges through contextually relevant and collaborative learning. Such contexts require learning environments that are responsive to local realities while remaining aligned with global expectations regarding higher-order competencies. Therefore, identifying students' learning needs within this context is not merely a preliminary research activity but a strategic step for ensuring that the proposed instructional model is educationally relevant, contextually responsive, and empirically grounded.

Based on the identified empirical, methodological, and contextual gaps, this study aimed to establish an empirical foundation for developing the PjBCL model through a comprehensive assessment of students' learning needs. Specifically, the study sought to (1) identify students' learning needs related to contextual learning, collaboration, higher-order competencies, learning preferences, and instructional support; (2) determine the design significance of these learning-need dimensions through descriptive profiling and integrated educational interpretation; and (3) synthesise the quantitative and qualitative findings into empirical learner design requirements that inform subsequent PjBCL model development.

Unlike previous studies that have primarily examined the effectiveness of Project-Based Learning or Collaborative Learning after instructional implementation, this study demonstrates how evidence generated through a systematic mixed-evidence needs assessment can be synthesised into learner design requirements within the EDR framework (Akker et al., 2013; McKenney & Reeves, 2019; Plomp, 2013). Its principal contribution is therefore the formulation of empirically grounded learner design requirements that provide an evidence-informed foundation for subsequent PjBCL model development while supporting instructional innovation aligned with the broader aspirations of SDG 4 (Quality Education). The conceptual pathway guiding this study is presented in Figure 1.

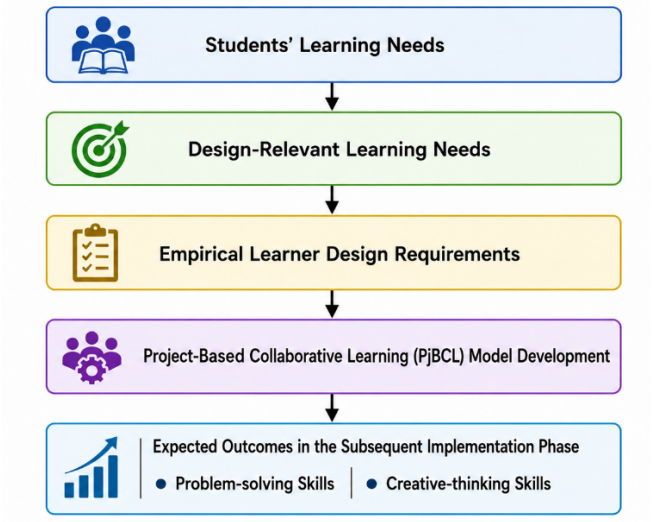

Figure 1. Conceptual pathway from students' learning needs to PjBCL model development.

As shown in Figure 1, students' learning needs were systematically analysed and synthesised into learner design requirements that will inform the subsequent development and evaluation of the PjBCL model. Consistent with EDR, this pathway establishes a transparent process for transforming empirical evidence into instructional design decisions (McKenney & Reeves, 2019; Plomp, 2013).

RESEARCH METHOD

Research design

This study employed EDR as the overarching research approach and reports the needs assessment phase of a broader project aimed at developing a PjBCL model. Educational Design Research was selected because it systematically integrates theoretical knowledge, contextual evidence, and iterative design activities to develop educational innovations that address authentic instructional problems (Akker et al., 2013; McKenney & Reeves, 2019; Plomp, 2013). In the present study, the needs assessment was undertaken to identify students' learning needs, interpret their design significance, and formulate empirically grounded learner design requirements for the subsequent development of the PjBCL model.

Educational Design Research provides a flexible framework for developing educational innovations through iterative cycles informed by empirical evidence (McKenney & Reeves, 2019; Plomp, 2013). This article reports only the needs assessment phase, which establishes the empirical basis for the subsequent design and development of the proposed PjBCL model.

To achieve these objectives, a cross-sectional survey was conducted during the needs assessment phase. Quantitative data were collected using a structured questionnaire administered to undergraduate students from multiple faculties and study programmes at Universitas Nusa Cendana. The questionnaire captured students' perceptions of current learning experiences, instructional expectations, and learning needs related to problem-solving, creative thinking, collaboration, and project-based learning. Three open-ended questions complemented the quantitative data by eliciting students' contextual perspectives regarding desirable instructional characteristics. The integration of quantitative and qualitative evidence enabled a comprehensive interpretation of students' learning needs and informed the formulation of empirical learner design requirements.

Participants

The main survey targeted undergraduate students enrolled in study programmes offering the compulsory course Culture, Dryland, Archipelagic Regions, and Tourism. Participants were recruited using non-probability purposive sampling with institutional stratification and voluntary participation. The online questionnaire was distributed through formal academic channels at the university, research office (LPPM), faculty, and study-programme levels to maximise institutional coverage and ensure broad disciplinary representation.

Rather than determining a minimum sample size through statistical estimation, the study adopted an operational recruitment strategy based on the academic characteristics of the target population. Because the course is scheduled differently across study programmes, the survey primarily targeted students who had completed or were completing the course. Recruitment therefore emphasised students in semesters 3–4 (approximately 60% of the recruitment target), while students in semester 5 and above

constituted approximately 40%. Although first- and second-semester students were not the primary target, responses from these students were retained when they met the inclusion criteria and completed the questionnaire voluntarily.

The recruitment process yielded 677 completed responses representing 43 study programmes across nine faculties. All submitted responses met the participant inclusion requirements and were retained for analysis. The two attention-check items were not used as respondent-exclusion criteria; they were excluded only from construct scoring and psychometric analyses.

This recruitment strategy enabled broad institutional participation across faculties and study programmes. However, because participation was voluntary and individual respondents were not selected randomly, the sample should be interpreted as a broad institutional sample rather than as a probability-based representation of the entire undergraduate population.

Table 1 summarises the demographic characteristics of the 677 participants included in the main survey. The respondents represented various academic backgrounds, semesters, and levels of prior learning experience, thereby providing a diverse empirical basis for identifying students' learning needs across higher education contexts.

Table 1. Respondent characteristics (N = 677)

Characteristic	Category	n	%
Gender	Male	265	39.1
	Female	412	60.9
Current semester	1–2	21	3.1
	3–4	329	48.6
	5–6	188	27.8
	>6	139	20.5
GPA	<2.75	16	2.4
	2.75–3.25	86	12.7
	3.26–3.50	193	28.5
	>3.50	382	56.4
Place of origin	Kupang City	254	37.5
	Other districts in NTT	399	58.9
	Outside NTT	24	3.5

Note: Percentages may not total 100% due to rounding.

Instrument development and pilot testing

The questionnaire was developed through an extensive review of the literature on Project-Based Learning, Collaborative Learning, contextual learning, higher-order thinking skills, and EDR. The initial instrument consisted of 70 items organised into seven conceptual dimensions representing the theoretical constructs underpinning the proposed PjBCL model (Akker et al., 2013; Jonassen, 2011; Plomp, 2013; Tan & Chapman, 2016).

A pilot study involving 35 undergraduate students was then conducted to evaluate the preliminary quality of the questionnaire before large-scale administration. The pilot study examined item comprehensibility, response patterns, corrected item–total correlations (CITC), and preliminary internal consistency using Cronbach's alpha. It was

not intended to establish construct validity through EFA because the pilot sample size was insufficient for factor extraction. Instrument refinement was based on the literature-derived construct framework and empirical evidence from the pilot test, including item comprehensibility, response patterns, corrected item–total correlations, and preliminary internal consistency.

The pilot-test results were used exclusively for instrument refinement rather than hypothesis testing or construct validation. Items with low corrected item–total correlations, ambiguous wording, overlapping content, or limited conceptual relevance were revised or removed to improve the overall quality of the instrument. This iterative refinement reduced the questionnaire from 70 to 51 closed-ended items. The revised instrument consisted of 49 substantive items designed to measure the intended learning-need constructs and two attention-check items incorporated solely as questionnaire quality-control items. Because the attention-check items were not designed to measure any theoretical construct, they were excluded from all psychometric and substantive analyses. In addition, the number of open-ended questions was reduced from five to three to improve response quality while retaining sufficient qualitative information for subsequent thematic analysis.

Following refinement, the final main-survey questionnaire comprised 51 closed-ended items organised into seven theoretically defined constructs: current learning experience, local context relevance, problem-solving skills, creative-thinking skills, collaboration and communication, preference toward PjBCL, and learning challenges. Of these, 49 substantive items represented the constructs included in the psychometric and descriptive analyses, whereas the two attention-check items were embedded within the current learning experience and creative-thinking sections exclusively to assess response quality. The two attention-check items were therefore excluded from construct scoring, reliability analysis, descriptive statistics, EFA, and all subsequent quantitative analyses. The questionnaire also included three open-ended questions designed to explore students' expectations regarding effective learning, perceived barriers to developing problem-solving and creative-thinking skills, and competencies considered essential for contemporary learning and future professional practice.

The refined questionnaire was then administered in the main needs assessment survey involving 677 undergraduate students. Unlike the pilot study, which served only as an initial instrument-refinement stage, the main-survey dataset constituted the basis for all psychometric and substantive analyses reported in this article. Internal consistency was evaluated using Cronbach's alpha, whereas the internal structure of the final questionnaire was examined through EFA based exclusively on responses obtained from the 677 participants. All psychometric evaluations, descriptive statistics, exploratory factor analyses, and quantitative–qualitative integration were based exclusively on the final main-survey dataset (N = 677).

Table 2. Instrument development and version history

Stage	Participants	Closed-ended items	Open-ended questions	Purpose	Role in the present study
Preliminary pilot instrument	35	70	5	Evaluate item clarity, preliminary reliability, and item performance	Instrument refinement only

Stage	Participants	Closed-ended items	Open-ended questions	Purpose	Role in the present study
Final main-survey instrument	677	51	3	Conduct the students' needs assessment	Source of all quantitative and qualitative analyses reported in this article

Note. The pilot and main-survey questionnaires were different instrument versions. Pilot responses were not included in the main needs assessment analyses.

Table 3. Structure of the final main-survey questionnaire

Construct	Administered items	Substantive items analysed	Excluded item
Current learning experience	8	7	B8, attention check
Local context relevance	6	6	None
Problem-solving skills	8	8	None
Creative-thinking skills	8	7	E8, attention check
Collaboration and communication	8	8	None
Preference toward PjBCL	7	7	None
Learning challenges	6	6	None
Total	**51**	**49**	**2 attention checks**

Only the 49 substantive items were included in reliability analysis, descriptive statistics, and exploratory factor analysis. The two attention-check items functioned solely as questionnaire quality-control items and were therefore excluded from all psychometric and substantive analyses because they did not represent the theoretical constructs investigated in this study.

Data collection

Following pilot testing and instrument refinement, the final questionnaire described in Section 2.3 was administered online to undergraduate students at Universitas Nusa Cendana. The questionnaire was distributed online through official institutional communication channels, beginning at the university level and then disseminated to faculties and study programmes to achieve broad disciplinary participation.

Participation was voluntary, and respondents received information regarding the objectives of the study, the anonymous nature of data collection, and the intended academic use of the findings before providing electronic informed consent. Eligibility was limited to active undergraduate students who were currently enrolled in, had previously completed, or had not yet taken the Culture, Dryland, Archipelagic Regions, and Tourism course, recognising that the semester placement of this course differs across study programmes.

An operational recruitment strategy was implemented to obtain broad institutional representation rather than to achieve a statistically predetermined sample size. Because

participation was voluntary and the questionnaire remained accessible throughout the data-collection period, the study obtained 677 completed responses representing 43 study programmes across nine faculties. All 677 completed responses met the participant inclusion requirements and were retained for analysis. The two attention-check items were not used as respondent-screening criteria. No personally identifiable information was collected, and all responses were stored anonymously and analysed exclusively for research purposes.

Data analysis

Quantitative data were analysed using IBM SPSS Statistics version 31. Before statistical analysis, the dataset was examined for completeness, duplicate records, response consistency, and response-range accuracy. Because the two attention-check items were incorporated solely as questionnaire quality-control items rather than respondent-screening criteria, they were excluded from all construct-based analyses. All psychometric evaluations and substantive analyses were therefore conducted using the remaining 49 substantive questionnaire items. Frequencies and percentages were used to describe participant characteristics, whereas means and standard deviations were calculated for the seven theoretically defined learning-need constructs. Current learning experience was treated as a descriptive baseline construct that provided contextual information about existing instructional conditions rather than representing a future instructional design priority.

Internal consistency of the final questionnaire was evaluated using Cronbach's alpha. The suitability of the 49 substantive items for exploratory factor analysis was examined using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. Exploratory factor analysis was conducted using principal axis factoring with direct oblimin rotation because correlations among the learning-need dimensions were theoretically expected. Items with primary factor loadings of 0.40 or greater were considered acceptable for interpretation. Cross-loading items were evaluated by considering the relative magnitude of competing loadings together with their theoretical interpretability before the final factor structure was retained. Factor retention was determined by considering eigenvalues, scree-plot inspection, factor-loading magnitude, cross-loading patterns, and theoretical interpretability. Construct means were then interpreted according to their empirical magnitude and educational significance to identify design-relevant learning needs for subsequent PjBCL model development. The analysis did not constitute a formal current-versus-expected gap calculation; therefore, the findings were interpreted as design-relevant quantitative profiles rather than as a conventional gap analysis or direct priority ranking.

The qualitative data derived from three open-ended questions were analysed using reflexive thematic analysis (Braun & Clarke, 2006, 2021),. The analysis involved familiarisation with the data, initial coding, code refinement, theme development, theme review, and theme definition before the qualitative findings were integrated with the quantitative results through joint display analysis to formulate empirical learner design requirements. A total of 2,031 response units generated by 677 students were analysed. All responses initially underwent semantic, codebook-assisted first-cycle coding, resulting in 61 preliminary codes. Because each written response could contain multiple meaning units, a single respondent could contribute to more than one coded response unit. Overlapping and conceptually similar codes were reviewed and consolidated into 42 refined codes, of which 37 substantive codes informed theme development, while five

transparency or counter-case codes were retained solely for audit purposes and excluded from the substantive thematic structure. During the research and manuscript-preparation processes, the authors used ChatGPT (OpenAI) to support language refinement and to conduct a secondary consistency check on 273 selected de-identified qualitative response units. No names, student identification numbers, email addresses, timestamps, or other directly identifying information were provided to the AI system. The AI tool was used solely to flag potential inconsistencies in code application and did not generate the codebook, assign codes, develop themes, or determine the final thematic structure. All coding decisions, code refinements, and theme development were subsequently reviewed and confirmed by the primary researcher. Accordingly, the AI system functioned exclusively as a consistency-checking aid and did not replace human interpretation or analytical judgement at any stage of the thematic analysis.

The refined codes were then examined for internal coherence, evidentiary support, and conceptual distinctiveness, resulting in six final themes representing students' learning needs. These qualitative themes were then integrated with the quantitative design-relevant learning needs through joint display analysis to examine convergence, complementarity, and explanatory relationships between the two datasets. This integration enabled the systematic translation of empirical findings into empirical learner design requirements that informed the subsequent development of the proposed PjBCL model. Theme frequencies indicate the number and proportion of unique respondents contributing to each theme and are reported descriptively to illustrate theme prevalence rather than inferential importance. This analytical procedure ensured that both quantitative and qualitative findings contributed systematically to the formulation of empirically grounded learner design requirements within the EDR framework.

RESULTS AND DISCUSSION

Results

Respondent characteristics

A total of 677 undergraduate students participated in this study, representing 43 study programmes across nine faculties at Universitas Nusa Cendana. Participants were recruited through institutional distribution and voluntary participation, following the recruitment procedures described in the Methods section. The respondents comprised students from the Faculty of Teacher Training and Education (51.6%), Faculty of Science and Engineering (21.4%), Faculty of Economics and Business (9.0%), Faculty of Social and Political Sciences (7.2%), Faculty of Agriculture (3.4%), Faculty of Medicine and Veterinary Medicine (3.0%), Faculty of Law (2.2%), Faculty of Public Health (1.3%), and Faculty of Marine and Fisheries (0.9%) (Table 1).

The respondents also demonstrated substantial academic experience. Female students accounted for 60.9% of the sample, while 39.1% were male. Most respondents were enrolled in semesters 3–4 (48.6%), followed by semesters 5–6 (27.8%) and semesters above six (20.5%). Because participation was open to students who were currently enrolled in, had previously completed, or had not yet taken the Culture, Dryland, Archipelagic Regions, and Tourism course, the sample reflected the diversity of curriculum implementation across study programmes where the course is offered at different semester levels. Overall, 96.9% of participants had completed more than one academic year and had experienced multiple instructional approaches during their university studies. In addition, 56.4% reported a cumulative grade point average above 3.50, while 28.5% had GPAs between 3.26 and 3.50, indicating that most respondents possessed

sufficient university learning experience to provide informed evaluations of instructional practices.

The geographical profile of the respondents further supports the contextual relevance of the needs assessment. More than half of the participants (58.9%) originated from districts outside Kupang City within East Nusa Tenggara Province, whereas 37.5% resided in Kupang City and 3.5% came from other provinces.

The respondents also reported considerable prior exposure to instructional practices relevant to the proposed model. Approximately 81.7% had completed the Culture, Dryland, Archipelagic Regions, and Tourism course, while 63.7% indicated frequent participation in project-based learning activities and 61.0% reported frequent experience with collaborative learning.

Questionnaire quality

Before the main survey was conducted, the preliminary questionnaire underwent pilot testing involving 35 undergraduate students from the Bachelor Programme of Electrical Engineering Education at Universitas Nusa Cendana. The pilot study aimed to evaluate item clarity, corrected item–total correlations (CITC), and preliminary internal consistency. The findings were used to refine item wording, improve construct representation, and enhance measurement quality. The revised questionnaire was then administered to the main survey involving 677 undergraduate students, whereas all psychometric analyses reported in this section were conducted exclusively using the final dataset.

Following the administration of the revised questionnaire to the main sample, the internal consistency of the final instrument was re-evaluated using Cronbach's alpha. The reliability analysis demonstrated excellent internal consistency across all measurement constructs, with Cronbach's alpha coefficients exceeding the recommended threshold of 0.70. The detailed reliability coefficients for each construct are presented in Table 4.

The internal structure of the final questionnaire was examined using exploratory factor analysis based exclusively on responses obtained from the 677 participants in the main survey. Prior to factor extraction, the suitability of the dataset for factor analysis was assessed through the Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The analysis yielded a KMO value of 0.970, indicating outstanding sampling adequacy according to Kaiser's classification. In addition, Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), confirming that the correlation matrix was appropriate for factor analysis. Together, the KMO and Bartlett results supported the factorability of the 49-item correlation matrix.

Table 4. Internal consistency reliability of the final questionnaire

Construct	Number of Items	Cronbach's Alpha	Interpretation
Current Learning Experience (CLE)	7	**0.925**	Excellent
Local Context Relevance (CTX)	6	**0.942**	Excellent
Problem-Solving Skills (PS)	8	**0.951**	Excellent
Creative Thinking Skills (CT)	7	**0.933**	Excellent
Collaboration and Communication (COL)	8	**0.937**	Excellent
Learning Preferences toward PjBCL (PREF)	7	**0.920**	Excellent

Construct	Number of Items	Cronbach's Alpha	Interpretation
Learning Challenges (CH)	6	**0.936**	Excellent

As shown in Table 4, Cronbach's alpha coefficients ranged from 0.920 to 0.951 for the seven questionnaire constructs.

Table 5. Sampling adequacy and factorability of the final questionnaire

Indicator	Result	Interpretation
Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy	**0.970**	Excellent sampling adequacy
Bartlett's Test of Sphericity (Approx. χ^2)	$\chi^2(1176) = 30{,}533.448$, $p < .001$	Correlation matrix suitable for factor analysis

Following confirmation of sampling adequacy and factorability, exploratory factor analysis was conducted using the 49 substantive questionnaire items to examine the empirical structure of students' learning needs.

Table 6. Summary of exploratory factor analysis results

EFA parameter	Result	Interpretation
Final questionnaire	51 items	49 substantive items and 2 attention-check items
Substantive items analysed	49	Used in all psychometric analyses
Extraction method	Principal Axis Factoring	Appropriate for identifying latent constructs
Rotation method	Direct Oblimin	Appropriate because factors were theoretically correlated
Number of empirical factors retained	6	Statistically and theoretically interpretable
Cumulative variance explained	67.71%	Satisfactory explanatory power
Communality range	0.435–0.799	All retained items exceeded minimum threshold (Adequate)
Rotated factor loading range	0.426–0.892	Acceptable to excellent

As shown in Table 6, exploratory factor analysis yielded a six-factor solution explaining 67.71% of the total variance. Retained items showed communalities ranging from 0.435 to 0.799 and rotated factor loadings ranging from 0.426 to 0.892 Although the questionnaire was initially developed around seven theoretical constructs, exploratory factor analysis yielded six empirical factors because the problem-solving and creative-thinking items converged into a single higher-order cognitive factor, whereas four learning-preference items (G1, G4, G5, and G6) loaded with the collaboration construct. The remaining preference items (G2, G3, and G7) formed a separate PjBCL preference factor. Exploratory factor analysis produced a statistically interpretable six-factor solution explaining 67.71% of the total variance.

Table 7. Empirical learning need dimensions identified through exploratory factor analysis

Factor	Empirical Construct	Main Items	Variance Explained
F1	Problem-solving and creative-thinking capability	D1–D8, E1–E7	21.00%
F2	Learning challenges	H1–H6	9.12%
F3	Local contextual relevance	C1–C6	13.27%
F4	Collaboration, communication, and learning orientation	F1–F8, G1, G4, G5, G6	12.95%
F5	Current learning experience	B1–B7	7.76%
F6	PjBCL preference	G2, G3, G7	3.62%
Total	—	—	**67.71%**

The exploratory factor analysis identified a six-factor empirical structure representing higher-order cognitive capability, learning challenges, contextual relevance, collaboration and learning orientation, current learning experience, and PjBCL preference. This structure was used to examine the internal organisation of the questionnaire and to inform the interpretation of the theoretically defined construct scores reported in the subsequent analyses.

Students' learning needs

The descriptive statistics revealed distinct profiles across the seven learning-need dimensions (Table 8). Local context relevance recorded the highest mean score (M = 4.333), followed by collaboration and communication (M = 4.223), current learning experience (M = 4.201), preference toward PjBCL (M = 4.100), problem-solving skills (M = 3.947), creative-thinking skills (M = 3.712), and learning challenges (M = 2.839). These descriptive statistics provide an empirical overview of students' responses across the seven measured dimensions and serve as the basis for the subsequent analyses.

Table 8. Descriptive statistics of students' learning-need dimensions

Learning-need dimension	N	Minimum	Maximum	Mean	SD
Current learning experience	677	1.14	5.00	4.201	0.684
Local context relevance	677	1.00	5.00	4.333	0.685
Problem-solving skills	677	1.38	5.00	3.947	0.719
Creative-thinking skills	677	1.57	5.00	3.712	0.776
Collaboration and communication	677	1.63	5.00	4.223	0.664
Preference toward PjBCL	677	1.86	5.00	4.100	0.687
Learning challenges	677	1.00	5.00	2.839	1.097

Local context relevance recorded the highest mean score (M = 4.333), followed by collaboration and communication (M = 4.223) and preference toward PjBCL (M = 4.100). Problem-solving skills (M = 3.947) and creative-thinking skills (M = 3.712) recorded lower mean scores than the three highest-rated dimensions. Learning challenges recorded the lowest mean score (M = 2.839) among the seven learning-need dimensions. These descriptive findings provide the quantitative foundation for the subsequent analyses of

design significance, qualitative themes, and integrated learner design requirements presented in Sections 3.4–3.6.

Analytical functions of students' learning-need dimensions

Because the seven quantitative dimensions measured different aspects of students' learning needs, their descriptive statistics were interpreted according to the conceptual meaning of each construct rather than being compared as equivalent deficit scores. Accordingly, Table 9 summarises the empirical profile and analytical function of the six future-oriented learning-need dimensions used in the subsequent analyses. The six future-oriented learning-need dimensions demonstrated different empirical profiles, whereas current learning experience served as a descriptive baseline. These profiles were subsequently integrated with the qualitative findings to examine convergence across quantitative and qualitative evidence. Table 9 presents the empirical profile, analytical function, and corresponding analytical interpretation of each future-oriented learning-need dimension used in the subsequent mixed-method integration.

Table 9. Design significance of students' learning-need dimensions

Learning-need dimension	Empirical profile	Analytical function	Empirical interpretation
Local context relevance	Strong desired condition (M = 4.333)	Enabling condition	Indicates a strong expectation for locally contextualised learning experiences.
Collaboration and communication	Strong desired condition (M = 4.223)	Enabling condition	Indicates a strong preference for structured collaborative learning
Preference toward PjBCL	High readiness (M = 4.100)	Readiness condition	Indicates high readiness for participation in PjBCL.
Problem-solving skills	Moderate-positive self-perception (M = 3.947)	Developmental competency	Indicates the need for continued development of problem-solving competency
Creative-thinking skills	Moderate-positive self-perception (M = 3.712)	Developmental competency	Indicates the need for continued development of creative-thinking competency.
Learning challenges	Relatively low barrier score (M = 2.839)	Barrier/support dimension	Indicates the importance of instructional support during project learning.

Table 9 summarises the different empirical profiles represented by the six future-oriented learning-need dimensions. These analytical profiles were subsequently integrated with the qualitative themes presented in Sections 3.5 and 3.6.

Qualitative themes explaining students' learning needs

The qualitative analysis provided contextual explanations for the quantitative learning-need dimensions identified in Sections 3.3 and 3.4. A total of 2,031 response units were generated from three open-ended questions completed by 677 students. Through iterative coding, refinement, and thematic analysis, the responses were organised into six interrelated themes representing students' expectations, perceived challenges, and recommendations for future instructional development. Because individual respondents

could contribute multiple meaning units across different themes, theme prevalence represents the proportion of unique respondents contributing to each theme rather than mutually exclusive categories. Theme prevalence should therefore be interpreted descriptively and not as an inferential measure of importance.

The most prevalent theme was Authentic Contextual Learning for Sustainable Regional Development, represented in the responses of 502 students (74.2%). Students frequently expected learning activities to engage with authentic issues related to local culture, dryland environments, archipelagic conditions, tourism, community life, and regional sustainability. This theme was identified in responses describing expectations for learning grounded in authentic local contexts and community realities.

One participant emphasised the importance of connecting learning with authentic local issues:

Original response (R001, Semester 3–4, I1):

> "*Pembelajaran sebaiknya dilakukan secara langsung di lapangan sehingga mahasiswa dapat memahami budaya masyarakat, kondisi lahan kering, dan potensi pariwisata di Nusa Tenggara Timur.*"

Translation (by the authors):

> "*Learning should be conducted through direct field experiences so that students can understand community culture, dryland environments, and tourism potential in East Nusa Tenggara.*"

This quotation exemplifies students' expectations for learning grounded in authentic local contexts and community realities.

The second theme, Collaborative Project-Based Inquiry, was represented by 413 students (61.0%). Students emphasised project work, teamwork, dialogue, shared responsibility, and collective problem solving as essential characteristics of meaningful learning. This theme reflects students' expectations for project work involving teamwork, dialogue, shared responsibility, and collaborative inquiry.

Another participant highlighted the importance of structured collaborative inquiry:

Original response (R012, Semester 5–6, I1):

> "*Pembelajaran sebaiknya melalui proyek kelompok yang melibatkan masyarakat sehingga mahasiswa belajar bekerja sama dan menyelesaikan masalah nyata.*"

Translation (by the authors):

> "*Learning should involve group projects with community participation so that students learn collaboration while solving authentic problems.*"

This response illustrates students' expectations for structured teamwork and collaborative inquiry.

Higher-Order Cognitive Competencies emerged in the responses of 394 students (58.2%). Students expected future learning to provide systematic opportunities for problem analysis, critical evaluation, creative idea generation, innovation, decision making, and solution development. Students described expectations for learning activities involving problem analysis, critical evaluation, creative idea generation, innovation, decision making, and solution development.

Three additional themes extended the quantitative findings. Learner Agency for Professional, Civic, and Global Readiness, represented by 373 students (55.1%), highlighted autonomy, confidence, self-regulation, communication, leadership, ethics, and professional responsibility.

One participant emphasised the importance of adaptability and locally responsive problem solving:

Original response (R636, Semester 5–6, I3):

> "*Adaptabilitas dan pemecahan masalah dengan sumber daya terbatas (frugal innovation). Bukan sekadar problem solving, tetapi kemampuan menciptakan solusi menggunakan bahan lokal, biaya minimal, dan kondisi nyata di Nusa Tenggara Timur.*"

Translation (by the authors):

> "*Adaptability and problem solving under resource constraints (frugal innovation) involve more than conventional problem solving. Students should be able to create workable solutions using local materials, minimal cost, and real conditions in East Nusa Tenggara.*"

This statement reinforces students' expectations regarding adaptability, resourcefulness, and contextually responsive problem solving.

Digital and Information Literacy for Learning, represented by 358 students (52.9%), emphasised the critical, productive, and ethical use of digital tools, information resources, data, and artificial intelligence. Finally, Instructional Support for Authentic Project Learning, represented by 220 students (32.5%), reflected students' need for sufficient resources, lecturer scaffolding, formative feedback, coherent learning stages, authentic assessment, and structured reflection. Another participant highlighted limitations in learning resources and initial lecturer guidance:

Original response (R098, Semester 3–4, I2):

> "*Akses untuk mendapatkan literatur yang masih kurang, kurangnya pengarahan dari pengajar di awal/dasar sebuah materi atau mata kuliah.*"

Translation (by the authors):

> "*Access to relevant literature remains limited, and lecturers provide insufficient guidance at the beginning or foundational stage of a course.*"

This quotation highlights students' expectations for adequate learning resources and lecturer guidance during project implementation.

Taken together, the six qualitative themes describe students' expectations regarding contextual learning, collaborative inquiry, higher-order competencies, learner agency, digital and information literacy, and instructional support. These themes provide the qualitative basis for the subsequent integration of quantitative and qualitative findings presented in Section 3.6. Illustrative quotations were purposively selected from respondents in Semesters 3–6 and are presented in the original Indonesian language with English translations prepared by the authors. Table 10 summarises the six qualitative themes, their prevalence, and central meanings.

Table 10. Qualitative themes explaining students' learning needs

Qualitative Theme	Unique Respondents	Prevalence	Central Meaning	Representative Expectation
Authentic contextual learning for sustainable regional development	502	74.2%	Learning should engage with authentic NTT realities, community contexts, and sustainability challenges.	Students expected learning connected to authentic local contexts.
Collaborative project-based inquiry	413	61.0%	Teamwork, dialogue, shared inquiry, and collective responsibility are central to meaningful learning.	Students expected structured teamwork and shared inquiry.
Higher-order cognitive competencies	394	58.2%	Problem solving, critical thinking, creativity, and innovation require	Students expected opportunities for analysis, creativity, and innovation.

Qualitative Theme	Unique Respondents	Prevalence	Central Meaning	Representative Expectation
			deliberate instructional development.	
Learner agency for professional, civic, and global readiness	373	55.1%	Students require autonomy, leadership, ethics, communication, and professional responsibility.	Students expected autonomy and responsibility.
Digital and information literacy for learning	358	52.9%	Digital tools, information, data, and AI should be used critically, productively, and ethically.	Students expected ethical and productive use of digital technologies.
Instructional support for authentic project learning	220	32.5%	Complex projects require scaffolding, resources, formative feedback, authentic assessment, and reflection.	Students expected adequate guidance, resources, and feedback.

Note. Theme prevalence was calculated using unique respondents. Multiple coding was permitted; therefore, percentages do not sum to 100%. Theme prevalence is descriptive and should not be interpreted as an inferential ranking of qualitative importance.

Translating integrated findings into empirical learner design requirements

The quantitative learning profiles presented in Sections 3.3–3.4 and the qualitative themes reported in Section 3.5 were integrated through a joint display to examine convergence, complementarity, and expansion. Five learner design requirements emerged from direct convergence and complementarity between the future-oriented quantitative dimensions and corresponding qualitative themes. Digital and information literacy emerged from the qualitative analysis as an additional cross-cutting requirement that extended, rather than directly replicated, the quantitative findings. Consequently, the integrated analysis produced six empirical learner design requirements: authentic contextual project design, structured collaborative inquiry, higher-order cognitive development, digital and information literacy, continuous scaffolding and authentic assessment, and learner agency and professional–civic responsibility. These requirements were derived from the convergence, complementarity, and expansion of the quantitative learning profiles and qualitative themes and are summarised in Table 11.

Table 11. Joint display integrating quantitative learning profiles, qualitative themes, and empirical learner design requirements

Quantitative learning-need dimension	Supporting qualitative theme	Integrated interpretation	Empirical learner design requirement	PjBCL design principle
Local context relevance, M = 4.333	Authentic contextual learning for sustainable regional development	Quantitative and qualitative findings consistently emphasised authentic local contexts.	Project activities should originate from local dryland, archipelagic, tourism, culture,	Authentic contextual project design

Quantitative learning-need dimension	Supporting qualitative theme	Integrated interpretation	Empirical learner design requirement	PjBCL design principle
			community, and sustainability contexts.	
Collaboration and communication, M = 4.223	Collaborative project-based inquiry	Convergent evidence highlighted the importance of structured teamwork, dialogue, shared inquiry, and collective responsibility.	Structured collaborative inquiry should be organised through explicit teams, roles, communication protocols, shared decisions, and reflection.	Structured collaborative inquiry
Preference toward PjBCL, M = 4.100	Learner agency for professional, civic, and global readiness	Convergent evidence indicated strong readiness for active project learning, learner autonomy, and responsibility.	Project learning should provide learner choice, leadership opportunities, ethical responsibility, and accountability.	Learner agency and responsibility
Problem-solving skills, M = 3.947, and creative-thinking skills, M = 3.712	Higher-order cognitive competencies	Convergent evidence highlighted the need for systematic development of analytical and generative thinking.	Project stages should include problem identification, evidence analysis, brainstorming, prototyping, evaluation, and iterative refinement.	Higher-order cognitive development
Learning challenges, M = 2.839	Instructional support for authentic project learning	Convergent evidence identified instructional support as an essential component of project learning.	Provide phased instructional support, formative feedback, authentic assessment, mentoring, and reflection.	Continuous scaffolding and authentic assessment
Cross-cutting support need	Digital and information literacy for learning	Qualitative evidence extended the quantitative findings by identifying digital and information literacy as a cross-cutting learning requirement that supports authentic project implementation, collaborative inquiry, higher-order cognition,	Integrate digital collaboration, source evaluation, data literacy, and ethical AI use throughout project implementation.	Digital and information literacy

Quantitative learning-need dimension	Supporting qualitative theme	Integrated interpretation	Empirical learner design requirement	PjBCL design principle
		learner agency, and instructional support.		

Figure 2 summarises the integration process through which the quantitative learning profiles and qualitative themes converged to produce six empirical learner design requirements for subsequent PjBCL model development.

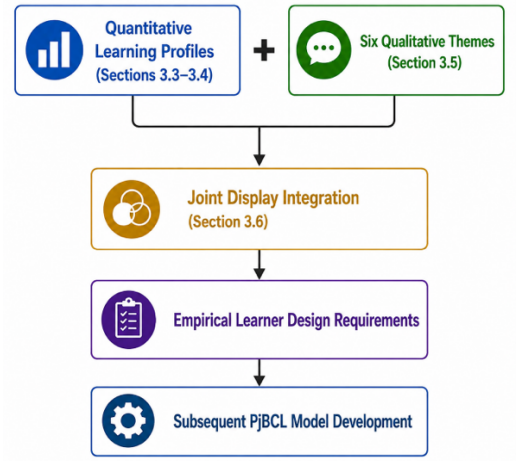

Figure 2. Integration of quantitative and qualitative findings into empirical learner design requirements.

Discussion

Interpretation of the findings

Contextual relevance

The finding that contextual relevance emerged as the strongest learning need indicates that students highly value learning experiences connected with authentic regional issues and real-world situations. Contextual examples were not perceived merely as illustrations of theoretical concepts; instead, students expected local environmental, socio-cultural, economic, and community challenges to become integral components of the learning process. This result suggests that contextual relevance is not simply an instructional preference but an essential condition for connecting disciplinary knowledge with practical application.

This interpretation is consistent with constructivist perspectives, which maintain that meaningful knowledge is developed through active engagement with authentic problems situated within relevant social and environmental contexts (Boss et al., 2015; Jonassen, 2011; Markham et al., 2003) argue that authentic projects enhance student engagement, knowledge transfer, and the application of disciplinary understanding to real-world challenges. The present findings therefore reinforce the importance of positioning authentic situations as the medium through which students investigate problems, construct understanding, and develop possible solutions.

In East Nusa Tenggara, issues associated with dryland environments, archipelagic communities, tourism, and local socio-economic development provide relevant contexts for project-based learning. Incorporating these issues into the proposed PjBCL model would enable students to integrate theoretical knowledge, collaborative inquiry, and

practical problem solving while responding to community needs. Accordingly, authentic regional problems should serve as starting points for project design, ensuring that learning activities are educationally meaningful, contextually responsive, and socially relevant.

Collaboration and communication

The consistently high score for collaboration and communication indicates that students perceive collaborative interaction as a fundamental component of meaningful learning rather than merely a classroom management strategy. Students expected learning environments characterised by shared responsibility, constructive dialogue, mutual support, and collective problem solving, reflecting their recognition that complex learning tasks are addressed more effectively through cooperation than through individual effort.

This interpretation aligns with previous studies identifying collaboration as a key element of twenty-first-century learning that promotes active participation, communication, shared responsibility, and collective knowledge construction (Barkley et al., 2014; Gillies, 2019; Johnson & Johnson, 2009) emphasises that effective collaboration depends on carefully structured instructional processes that foster positive interdependence, individual accountability, and productive interaction rather than simply assigning students to work in groups. The present findings reinforce this perspective by demonstrating that students value collaboration as an intentionally designed learning process.

The qualitative findings further indicate that students expected collaborative projects to involve shared inquiry, collective decision making, and meaningful engagement with local communities where appropriate. These expectations suggest that collaboration should extend beyond interpersonal communication to support the co-construction of knowledge and the integration of diverse perspectives for addressing authentic problems. Accordingly, the proposed PjBCL model should embed structured collaboration throughout every stage of the project cycle by incorporating explicit team formation, clearly defined member roles, collaborative inquiry, communication protocols, peer feedback, and collective reflection. Such design decisions ensure that collaboration functions as a core instructional principle rather than merely as a classroom activity.

Preference toward project-based collaborative learning

The high level of students' preference toward Project-Based Collaborative Learning (PjBCL) indicates strong readiness to engage in active and collaborative learning environments. Rather than favouring conventional teacher-directed instruction, students expressed positive expectations toward learning experiences that encourage participation, shared responsibility, and authentic project engagement. This finding suggests that learner readiness constitutes an important enabling condition for the successful implementation of instructional innovation.

This interpretation is consistent with previous studies demonstrating that project-based learning enhances motivation, engagement, and responsibility when students actively participate in meaningful projects (Bell, 2010; Kokotsaki et al., 2016; Thomas, 2000). These studies argue that engagement increases when learners perceive learning activities as personally meaningful and connected to authentic situations requiring investigation and collaborative decision making. The present findings extend this

perspective by showing that students are prepared to participate actively in learner-centred instructional approaches rather than functioning as passive recipients of knowledge.

The qualitative findings further demonstrate that students expected opportunities to contribute to project planning, decision making, problem solving, and reflection throughout the learning process. These expectations indicate that learner readiness should be viewed not merely as acceptance of instructional innovation but as willingness to assume active responsibility for learning. Accordingly, the proposed PjBCL model should provide systematic opportunities for learner autonomy, shared decision making, project ownership, and reflective participation throughout project implementation, thereby strengthening students' engagement, responsibility, and commitment to meaningful learning.

Problem-solving and creative thinking

Although students reported moderately positive perceptions of their problem-solving and creative-thinking abilities, these competencies received lower mean scores than contextual relevance, collaboration, and preference toward PjBCL. This pattern suggests that students recognise higher-order competencies as essential for future academic and professional success while acknowledging the need for more systematic opportunities to develop them through authentic learning experiences.

This interpretation is consistent with previous studies showing that higher-order competencies develop most effectively through authentic inquiry, collaborative investigation, iterative problem solving, and reflective learning rather than passive knowledge transmission (Hmelo-Silver, 2004; Tan & Chapman, 2016). The exploratory factor analysis further supports this interpretation by demonstrating that problem-solving and creative-thinking items converged into a broader higher-order cognitive dimension. Rather than representing separate abilities, students appeared to perceive analytical reasoning and creative idea generation as complementary processes operating simultaneously during project work, consistent with (Cropley, 2006) argument that creativity and problem solving mutually reinforce one another in complex learning environments.

These findings suggest that the proposed PjBCL model should integrate higher-order competency development across the entire project cycle. Project activities should therefore incorporate authentic problem identification, evidence gathering, collaborative analysis, idea generation, prototype development, evaluation, and iterative refinement as interconnected learning processes. Embedding these processes systematically within project implementation will enable the proposed PjBCL model to strengthen students' analytical reasoning, creativity, and capacity to address complex real-world challenges.

Learning challenges

Although learning challenges received the lowest mean score among the quantitative dimensions, the findings should not be interpreted as indicating that instructional support is unimportant. Instead, students regarded project challenges as manageable when accompanied by clear guidance, accessible learning resources, timely formative feedback, and well-organised learning activities. The qualitative findings consistently highlighted these forms of support as important conditions for successful project implementation.

This interpretation is consistent with constructivist perspectives, which emphasise that meaningful learning occurs when appropriate scaffolding enables students to perform increasingly complex tasks while gradually assuming greater responsibility for their own learning. Previous studies likewise demonstrate that effective project-based learning depends on continuous facilitation, formative assessment, and reflective dialogue to sustain learner engagement and deepen understanding throughout the learning process. Accordingly, instructional support should be viewed as an integral component of project design rather than as supplementary assistance provided only when learning difficulties arise.

The qualitative evidence further indicates that students expected lecturers to act as facilitators, mentors, feedback providers, and learning coordinators throughout project implementation. These findings suggest that the proposed PjBCL model should incorporate structured scaffolding through staged project activities, continuous formative feedback, collaborative monitoring, authentic assessment, and regular reflection. By embedding these instructional supports into the model design, PjBCL is expected to enhance project feasibility, sustain learner engagement, and progressively strengthen students' confidence in undertaking authentic project work.

Digital and information literacy

Digital and information literacy emerged as a cross-cutting learning requirement in the qualitative findings, although it was not measured as a separate quantitative construct in the questionnaire. Students emphasised the need to use digital tools, information resources, data, and artificial intelligence critically, productively, and ethically across learning activities. This finding indicates that digital literacy should not be treated as an isolated technical skill but as an enabling capability supporting inquiry, collaboration, problem solving, creativity, and responsible participation in project-based learning.

The cross-cutting character of this requirement is particularly relevant to PjBCL because students are expected to search for and evaluate information, collaborate through digital environments, analyse data, communicate project outcomes, and use emerging technologies throughout the project cycle. Accordingly, the proposed PjBCL model should embed source evaluation, digital collaboration, data literacy, information ethics, and responsible AI use across its instructional stages rather than positioning digital literacy as a separate learning activity.

Taken together, the five convergent evidence domains and the cross-cutting digital and information literacy requirement reveal that students' learning needs constitute an integrated pedagogical framework rather than a collection of separate instructional preferences. Contextual learning, structured collaboration, learner readiness and agency, higher-order cognitive development, systematic instructional support, and responsible digital engagement interact to support meaningful and effective learning experiences. Collectively, these findings provide a robust empirical foundation for formulating the six learner design requirements that underpin the subsequent development of the proposed PjBCL model.

Contribution to educational design research

Educational Design Research (EDR) emphasises that instructional innovations should be developed through iterative interactions among educational theory, empirical investigation, and practical implementation (McKenney & Reeves, 2019; Plomp, 2013). Consistent with this perspective, the present study demonstrates that systematic learner

needs assessment constitutes a strategic empirical foundation for instructional model development rather than merely serving as a preliminary diagnostic activity. By positioning learner needs analysis as the starting point of the design process, this study illustrates how empirical evidence can directly inform subsequent instructional design, prototype development, and evaluation within the EDR framework.

This study also reinforces previous research highlighting the importance of aligning learner characteristics, learning objectives, instructional strategies, and contextual conditions during instructional design (Branch, 2009; McKenney & Reeves, 2019). However, the findings extend existing knowledge by demonstrating that students' learning needs are multidimensional and interconnected rather than isolated instructional preferences. The integration of quantitative and qualitative evidence further provides a more comprehensive understanding of learner expectations, allowing instructional requirements to be formulated from multiple complementary sources of evidence.

A further contribution of this study lies in introducing the concept of *learner design requirements* as an operational bridge between needs assessment and instructional model development. While previous studies have frequently reported learner needs descriptively, relatively few have translated those findings into explicit design requirements that systematically guide subsequent model development. By converting integrated empirical evidence into coherent design requirements, the present study offers a practical mechanism through which learner-centred evidence can inform instructional design decisions within an Educational Design Research framework.

Implications for sustainable higher education (SDG 4)

The findings of this study have important implications for sustainable higher education, particularly in supporting the implementation of Sustainable Development Goal 4 (SDG 4), which emphasises inclusive, equitable, and quality education while promoting lifelong learning opportunities for all. Rather than viewing educational quality solely in terms of curriculum content or academic achievement, the present findings suggest that sustainable higher education also depends on learning environments that actively develop students' higher-order competencies through authentic, collaborative, and learner-centred instructional practices. The six learner design requirements formulated through the integrated analysis demonstrate that students expect learning experiences that are meaningful, participatory, contextually responsive, cognitively challenging, adequately supported, and digitally responsible.

This interpretation is consistent with previous studies arguing that higher education plays a central role in preparing graduates to address increasingly complex social, environmental, and economic challenges through active and competency-based learning approaches. This interpretation is consistent with Education for Sustainable Development (ESD), which emphasises that higher education should cultivate key competencies such as critical thinking, collaboration, creativity, integrated problem solving, and responsible action through learner-centred and contextually meaningful learning experiences. These competencies are recognised as fundamental for achieving SDG 4, particularly Target 4.7, which seeks to equip learners with the knowledge and skills required to promote sustainable development. The present findings reinforce these perspectives by providing empirical evidence that students themselves identify these competencies as priorities for future learning and instructional innovation (UNESCO, 2020).

The prominence of contextual relevance further suggests that sustainable higher education should not rely exclusively on globally oriented learning materials but should also integrate authentic local contexts into instructional practice. Within the context of East Nusa Tenggara, issues related to dryland environments, archipelagic communities, tourism, and local socio-economic development provide meaningful opportunities for students to connect academic knowledge with community needs. Such contextual learning not only enhances the relevance of higher education but also encourages students to develop solutions that contribute to sustainable regional development while strengthening their sense of social responsibility.

The findings also highlight that achieving quality education requires more than adopting innovative instructional models. Sustainable educational improvement depends equally on structured collaboration, learner readiness, higher-order cognitive development, and continuous instructional support throughout the learning process. Consequently, educational innovation should be understood as a comprehensive process that integrates curriculum, pedagogy, assessment, and learning support rather than introducing isolated teaching techniques. This perspective aligns with the broader objective of SDG 4 to improve not only access to education but also the quality and relevance of learning experiences.

Taken together, these findings indicate that the proposed Project-Based Collaborative Learning model has the potential to contribute to sustainable higher education by providing an evidence-informed instructional framework that aligns learner needs with the development of competencies required in contemporary society. Although the present study was conducted within a specific institutional context, the identified learner design requirements may provide useful guidance for developing contextually responsive instructional innovations in comparable higher education settings seeking to strengthen educational quality in support of SDG 4.

Implications for PjBCL development

Building upon the contributions outlined in the previous section, the findings of this study provide a clear empirical foundation for translating learner needs into the design of the proposed Project-Based Collaborative Learning (PjBCL) model. Rather than deriving instructional components solely from established pedagogical theories, the model should be developed by systematically aligning its design with the six empirical learner design requirements formulated through the integration of quantitative and qualitative evidence. This approach ensures that the proposed model is not only theoretically sound but also responsive to students' documented learning needs and the contextual realities of higher education.

The prominence of contextual relevance indicates that authentic local issues should become the organising principle for project selection. Accordingly, project activities should be centred on problems that reflect students' surrounding environmental, social, economic, and cultural contexts, enabling learners to connect disciplinary knowledge with community-based problem solving. This design decision strengthens the authenticity and contextual responsiveness of project-based learning while increasing its educational relevance.

The findings concerning collaboration and communication suggest that collaborative learning should be embedded systematically throughout the project cycle rather than limited to group assignments. Project implementation should therefore incorporate structured team formation, clearly defined member roles, collaborative inquiry, shared

decision making, peer feedback, and reflective discussion. These instructional structures are expected to strengthen collective responsibility while promoting meaningful interaction and knowledge co-construction.

Students' strong preference for learner-centred learning further indicates that the model should maximise learner autonomy and active participation. Project activities should provide opportunities for students to contribute to planning, investigation, implementation, evaluation, and reflection. Positioning students as active participants throughout the learning process is expected to increase engagement, ownership, and responsibility for learning outcomes.

The findings related to problem-solving, creative thinking, and learning challenges further demonstrate that authentic projects alone are insufficient for developing higher-order competencies. The proposed model should therefore integrate iterative inquiry, evidence analysis, idea generation, prototype development, formative feedback, reflective evaluation, and systematic scaffolding across every stage of project implementation. These elements should function as an integrated instructional system that progressively supports students as they engage with increasingly complex learning tasks.

Collectively, these design implications demonstrate that the proposed PjBCL model represents more than a combination of project-based and collaborative learning approaches. Its distinctive contribution lies in translating empirically identified learner needs into coherent instructional design decisions that guide project organisation, collaboration structures, instructional support, learning activities, and assessment. Taken together, these design implications provide a coherent roadmap for the subsequent phases of prototype development, expert validation, formative evaluation, and field implementation, thereby ensuring that the proposed PjBCL model remains empirically grounded, theoretically robust, and contextually responsive.

Overall, the Discussion demonstrates that the identified learner needs not only explain students' current learning expectations but also provide a coherent empirical basis for developing an instructional model capable of strengthening higher-order competencies through contextually responsive, collaborative, and learner-centred learning. These findings therefore bridge empirical needs assessment with evidence-informed instructional model development within an Educational Design Research framework.

CONCLUSION

Fundamental Finding: This study established students' learning needs as the empirical foundation for developing a Project-Based Collaborative Learning (PjBCL) model. The findings identified key learner needs related to contextual relevance, collaboration and communication, readiness for PjBCL, problem-solving and creative-thinking development, instructional support, and digital and information literacy. By integrating quantitative and qualitative evidence, the study generated six empirical learner design requirements that provide a robust evidence-based foundation for learner-centered instructional model development within the Educational Design Research (EDR) framework. **Implication:** The study demonstrates a transparent evidence-to-design process through which systematically collected learner data can be transformed into practical instructional design requirements. These findings offer valuable guidance for educators and instructional designers in developing learning models that are responsive to students' needs, contextual learning environments, and twenty-first-century competencies. Furthermore, the study contributes to the achievement of SDG 4 (Quality

Education) by promoting evidence-informed, student-centered instructional innovation that enhances higher-order thinking, collaboration, learner autonomy, and authentic learning experiences in higher education. **Limitation:** Although the study involved participants from 43 undergraduate study programs across nine faculties, the findings were derived from a single university using voluntary non-probability sampling and self-reported survey data. In addition, the qualitative findings were based on written responses, which may not fully capture the depth and diversity of students' perspectives. Therefore, the generalizability of the findings should be interpreted with caution. **Future Research:** Future research should utilize the empirical learner design requirements identified in this study to develop, refine, and iteratively evaluate the proposed PjBCL model throughout the Educational Design Research process. Subsequent studies are also encouraged to examine the effectiveness of the model across different higher education institutions, disciplines, and learning contexts to strengthen its applicability, scalability, and contribution to sustainable educational innovation.

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AUTHOR CONTRIBUTIONS

Zet Yulius Baitanu contributed to the conceptualization of the study, methodology, investigation, data curation, formal analysis, visualization, preparation of the original manuscript draft, and project administration. **Suryanti** contributed to supervision, methodology, and critical review and editing of the manuscript. **Lamijan Hadi Susarno** contributed to supervision and critical review and editing of the manuscript. All authors have read, reviewed, and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known financial or non-financial competing interests that could have influenced the work reported in this article.

ETHICAL COMPLIANCE STATEMENT

Institutional permission for the main needs-assessment survey was obtained through State University of Surabaya (UNESA) Research Permission Letter No. A/1522/UN38.1/PP.11.01/2025, dated March 10, 2025, and Universitas Nusa Cendana Research Data Collection Permission Letter No. 1448/UN15.22/LT/2025, dated September 15, 2025. Pilot testing of the questionnaire was conducted under separate permission from the Faculty of Science and Engineering, Universitas Nusa Cendana, through Letter No. A/1524/UN38.1/PP.11.01/2025, dated March 10, 2025. Participation was voluntary, electronic informed consent was obtained, no directly identifying personal information was collected, and all responses were treated confidentially.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

During the research and manuscript-preparation processes, the authors used ChatGPT (OpenAI) to support language refinement and to conduct a secondary consistency check on selected de-identified qualitative response units. The AI system was used solely to assist in identifying potential inconsistencies in code application and improving the clarity of academic writing. It did not independently generate the final codebook, assign qualitative codes, develop themes, interpret findings, or make methodological decisions. No directly identifying participant information was shared with the AI system. All outputs were critically reviewed, verified, and approved by the authors, who retain full responsibility for the accuracy, originality, confidentiality, and integrity of the research and manuscript.

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