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Building intercultural competence in Indonesian engineering education through faculty development, institutional support, and teaching innovation

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Abstract

Globalization and increasing cultural diversity in higher education demand innovative teaching approaches that support the development of intercultural competence. This study develops and tests a process-oriented model examining how undergraduate engineering students' perceptions of faculty development support and institutional support are associated with students' cultural intelligence, intercultural competence, perceptions of interculturally informed teaching practices, intercultural student engagement, and student learning outcomes. Survey data were collected from 814 undergraduate engineering students in Indonesia and analyzed using Structural Equation Modeling (SEM). The findings indicate that students who perceived stronger faculty development support reported higher levels of cultural intelligence, which was positively associated with intercultural competence and greater perceived implementation of interculturally informed teaching practices. Students who perceived more interculturally informed teaching practices also reported higher intercultural student engagement, which was positively associated with higher self-reported student learning outcomes. These findings provide an integrated perspective on how undergraduate engineering students perceive the relationships among institutional support, faculty practices, intercultural development, and learning outcomes, offering practical insights for supporting more inclusive and globally responsive engineering education.

Keywords Faculty development, Cultural intelligence, Intercultural competence, Student engagement, Indonesia higher education, Engineering education, Intercultural teaching, PLS-SEM

1 Introduction

Increasing cultural diversity within universities has fundamentally reshaped teaching and learning environments in higher education. As institutions become more internationally connected and student populations increasingly multicultural, faculty members



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are expected not only to deliver disciplinary knowledge but also to facilitate intercultural learning that prepares students for global professional environments. The ability to engage effectively with cultural diversity has therefore become an essential component of higher education, particularly in disciplines such as engineering and technical education, where graduates frequently collaborate across national and cultural boundaries [46]. In response to these changes, scholars have increasingly emphasized the importance of intercultural competence in higher education. Intercultural competence refers to the ability to interact effectively and appropriately with individuals from different cultural backgrounds, encompassing cognitive, behavioral, and attitudinal dimensions of cross-cultural interaction [54]. In university classrooms, the development of such competence is closely linked to culturally responsive teaching practices that acknowledge diverse perspectives and are associated with more inclusive learning environments. Previous studies suggest that interculturally informed teaching practices are positively associated with higher levels of student engagement and deeper learning by enabling students to connect academic knowledge with diverse cultural experiences [13, 50]. However, despite the growing recognition of intercultural learning in higher education, the mechanisms through which institutional and pedagogical factors contribute to the development of these outcomes remain insufficiently understood.

One important factor shaping intercultural learning is faculty capability. Faculty members play a central role in facilitating intercultural interactions in classrooms, yet their ability to do so is often associated with the level of professional support provided by institutions [19]. Faculty development initiatives, including workshops, training programs, and mentorship opportunities, have been associated with higher levels of educators' cultural intelligence and greater capability to function effectively in culturally diverse settings [18, 43]. Higher levels of cultural intelligence have been associated with educators' ability to recognize cultural differences, adapt teaching approaches, and implement inclusive learning environments that support diverse student populations [46]. Likewise, institutional support structures, such as policies, resources, and strategic initiatives, have been suggested to be associated with the development and implementation of intercultural competencies in teaching practices [50].

Although prior research has examined constructs such as cultural intelligence, intercultural competence, teaching practices, and student engagement, these elements have often been investigated independently [4, 21, 29]. As a result, existing studies provide limited insight into how faculty development initiatives and institutional support interact with faculty competencies and are associated with teaching practices and student learning outcomes. In particular, there remains a lack of integrative models that explain the sequential relationships through which faculty capabilities are linked to intercultural student engagement and perceived learning outcomes within higher education contexts [41]. This limitation is especially evident in technical and engineering education, where intercultural learning has received comparatively less attention despite the increasingly global nature of professional practice [10]. Addressing this gap, the present study proposes and empirically tests a process-oriented model of intercultural learning in higher education from the perspective of undergraduate engineering students. The model integrates students' perceived Faculty Development Support (FDS), Cultural Intelligence (CI), Intercultural Competence (IC), perceived Interculturally Informed Teaching Practices (IITP), Intercultural Student Engagement (ISE), students' perceived Institutional

Support (IS), and Student Learning Outcomes (SLO). By examining the direct and indirect relationships among these variables, the study seeks to explain how students perceive the interplay between institutional support, faculty practices, their intercultural competencies, and learning outcomes within engineering education.

This study advances research on higher education innovation by providing an integrated framework that examines intercultural learning processes from the perspective of undergraduate engineering students. First, the study develops a framework that examines how students perceive the relationships among faculty development support, institutional support, interculturally informed teaching practices, intercultural competencies, student engagement, and learning outcomes. Second, it provides empirical evidence regarding the proposed sequential pathways among students' perceived faculty and institutional support, intercultural competencies, engagement, and learning outcomes. Third, by focusing on undergraduate students in technical and engineering education, the study extends existing research on intercultural education to a disciplinary context that has received relatively limited attention. Through these contributions, the study offers a broader understanding of intercultural learning processes from students' perspectives while providing practical insights for universities seeking to support inclusive and globally responsive learning environments.

2 Literature review and hypotheses

2.1 Faculty development and cultural intelligence

Faculty development initiatives have long been recognized as important mechanisms related to educators' professional competencies and pedagogical effectiveness [24]. In higher education, these programs are increasingly associated with efforts to develop cultural intelligence (CI) among faculty members, reflecting the growing diversity of student populations and the globalized nature of education. CI is conceptualized as the capability to function effectively across culturally diverse settings, encompassing cognitive, motivational, and behavioral dimensions [48]. Faculty members with higher levels of CI are generally more likely to recognize cultural nuances, adapt their teaching strategies, and support inclusive learning environments. Previous studies suggest that targeted faculty development support (FDS), including workshops, training, mentorship, and access to intercultural resources, is associated with higher levels of CI among educators [36].

Despite the acknowledged importance of FDS in developing CI, prior studies have predominantly focused on direct training outcomes or generic professional development, often neglecting the indirect associations among CI, teaching practices, and student outcomes. For instance, while [39] highlighted the effectiveness of faculty workshops in improving intercultural awareness, they did not investigate how such improvements are associated with perceptions of interculturally informed teaching practices (IITP) or student learning outcomes (SLO). This gap suggests the need for an integrative approach that considers how faculty development support is associated with teaching practices and student learning outcomes through interconnected processes.

2.2 Intercultural competence and teaching practices

Intercultural competence (IC) refers to the ability to interact effectively, appropriately, and respectfully with individuals from diverse cultural backgrounds [52]. Within the

broader literature, cultural intelligence (CI) has been conceptually linked to intercultural competence, and higher levels of intercultural competence have been associated with implementing interculturally informed teaching practices (IITP), which incorporate culturally responsive strategies into curricula and classroom practices [34]. Such practices may include integrating diverse cultural perspectives, using inclusive learning materials, and designing learning activities that acknowledge multicultural contexts. Previous studies have also reported positive associations between intercultural competence and student engagement in culturally diverse learning environments [49]. However, existing research has often examined intercultural competence in isolation, with limited attention to its potential role within broader models that link cultural intelligence to students' perceptions of interculturally informed teaching practices. This gap highlights the need for a more integrated framework that examines how these constructs are associated with one another from the perspective of undergraduate students.

Recent studies emphasize the importance of linking faculty CI and IC to teaching practices. For example, [46] highlighted that faculty with advanced CI were more confident in implementing inclusive teaching strategies. However, the study did not systematically examine the associations between these competencies and student engagement and learning outcomes. It highlights a persistent gap: while CI and IC are foundational for intercultural education, the sequential relationships among CI, IC, IITP, and student learning outcomes remain underexplored, particularly in engineering and STEM education contexts where cultural diversity is increasingly prominent.

2.3 Intercultural student engagement and learning outcomes

Intercultural student engagement (ISE) refers to the extent to which students actively participate in learning activities that promote cultural understanding and interaction. Engagement is widely recognized as a key determinant of academic achievement and holistic development [1]. Previous literature suggests that faculty-mediated IC and IITP are positively associated with ISE, as students exposed to inclusive teaching practices tend to report more meaningful participation in discussions, collaborative projects, and cross-cultural activities [26, 31]. Students who report higher levels of engagement also tend to report stronger higher-order cognitive skills, intercultural awareness, and learning outcomes, reinforcing the close relationship between faculty competencies and student achievement [8].

However, much of the existing research isolates student engagement from faculty-driven interventions, often focusing solely on individual-level outcomes [28]. The lack of integrative models linking faculty development, CI, IC, IITP, ISE, and SLO represents a critical gap in the literature. While previous studies have reported positive associations between intercultural teaching practices and student engagement, the mechanisms and pathways through which faculty development is associated with student learning outcomes (SLO), through multiple sequential processes, remain under-investigated.

2.4 Institutional support and its role

Institutional support (IS) emerges as a key contextual factor associated with faculty development and educational outcomes. IS encompasses policies, resources, infrastructure, and administrative support that facilitate professional development and intercultural education [9, 32]. The literature indicates that institutions providing stronger

support are associated with greater opportunities for faculty members to develop cultural intelligence (CI), implement intercultural teaching practices (IITP), and promote intercultural student engagement (ISE), which may subsequently be associated with more positive student learning outcomes (SLO) [33]. The presence of structured IS mechanisms, such as dedicated intercultural training programs, mentorship networks, and resource allocation, has been reported to strengthen the implementation of faculty development initiatives [6]. Nevertheless, prior studies rarely model the relationships between IS, FDS, and the sequential mediators (CI, IC, IITP, ISE) associated with SLO, leaving the integrated pathway underexplored.

2.5 Hypotheses development

Based on the integrative framework proposed in this study, thirteen hypotheses were formulated to examine the associations among FDS, CI, IC, IITP, ISE, IS, and SLO. These hypotheses are grounded in prior literature highlighting the associations among faculty development, cultural awareness, institutional resources, teaching practices, and student learning outcomes.

First, the study hypothesizes that students' perceived FDS is positively associated with students' CI (H1). Students who perceive that their lecturers receive adequate support, training, and resources for intercultural learning initiatives also tend to report higher levels of cultural intelligence [46]. Higher levels of CI are positively associated with higher levels of IC (H2), consistent with students' reported ability to understand, appreciate, and interact effectively across cultural contexts [50]. Higher levels of IC are positively associated with greater perceived implementation of IITP (H3), as students with stronger intercultural competence may be more aware of culturally responsive instructional approaches within their learning environment. Higher perceived implementation of IITP is positively associated with higher levels of ISE (H4), consistent with previous research indicating that inclusive teaching practices are associated with greater participation in culturally diverse learning experiences [7]. Finally, higher levels of ISE are positively associated with SLO (H5), consistent with previous research reporting positive associations between meaningful intercultural learning experiences and students' academic development.

Students' perceived IS is also hypothesized to be positively associated with students' intercultural development and learning outcomes. Specifically, higher perceived IS is positively associated with higher levels of IC (H6) and SLO (H7), as supportive institutional policies, resources, and learning environments are generally associated with students' intercultural development. In addition to these direct associations, several mediation hypotheses were formulated to examine the sequential associations among the study variables. Specifically, CI is hypothesized to mediate the association between students' perceived FDS and IC (H8). IC is hypothesized to mediate the association between CI and perceived IITP (H9). Perceived IITP are hypothesized to mediate the association between IC and ISE (H10). ISE is hypothesized to mediate the association between perceived IITP and SLO (H11). Finally, students' perceived FDS is hypothesized to be indirectly associated with SLO through the sequential mediation of CI, IC, perceived IITP, and ISE (H12). Likewise, students' perceived IS is hypothesized to be indirectly associated with SLO through the sequential mediation of IC, perceived IITP, and ISE (H13). These hypotheses represent the proposed pattern of associations among

students' perceptions of faculty support, institutional support, interculturally informed teaching practices, intercultural competencies, student engagement, and learning outcomes. The hypotheses developed above are illustrated in Fig. 1, which presents the theoretical framework.

3 Method

3.1 Research design

This study employs a quantitative research design to explore the relationships between faculty development support, cultural intelligence, intercultural competence, interculturally informed teaching practices, intercultural student engagement, institutional support, and student learning outcomes within a technical education context. The primary focus of this research is to test a hypothesized model using Structural Equation Modeling (SEM), a method well-suited for comprehensively examining direct and indirect effects among multiple variables [22]. The study aims to empirically examine the proposed model by investigating how students' perceptions of faculty development support and institutional support are associated with intercultural competencies and student learning outcomes. The research approach emphasizes the importance of understanding these relationships to provide actionable insights for informing educational practices and policies, particularly in environments that value intercultural competencies. The research design, therefore, supports the rigorous testing of 13 hypotheses, addressing direct and indirect effects, to contribute meaningfully to the existing literature on intercultural competencies in education.

Although the conceptual framework includes faculty- and institution-related constructs, all variables in this study were measured using undergraduate engineering students as the unit of analysis. Consequently, Faculty Development Support (FDS), Institutional Support (IS), and Interculturally Informed Teaching Practices (IITP) represent students' perceptions of the support, teaching practices, and educational environment provided by their lecturers and institution rather than direct assessments of faculty competencies or institutional performance. In contrast, Cultural Intelligence (CI), Intercultural Competence (IC), Intercultural Student Engagement (ISE), and Student Learning Outcomes (SLO) represent students' self-reported competencies, experiences, and learning outcomes. Accordingly, all hypothesized relationships should be interpreted as associations among students' perceptions and self-reported experiences.

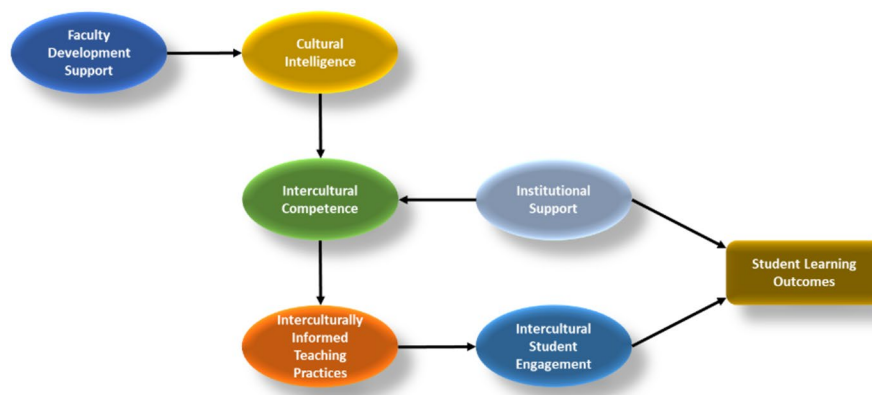


Fig. 1 Model of theoretical framework

3.2 Population and sample

The population for this study comprised all undergraduate students enrolled in the Faculty of Engineering at a public university in Indonesia during the January-June 2026 semester. The Faculty of Engineering includes students from six engineering departments, namely Electronic Engineering, Electrical Engineering, Mechanical Engineering, Automotive Engineering, Civil Engineering, and Mining Engineering, providing an appropriate context for examining intercultural competence within engineering education. The inclusion criterion for participation was enrollment as an undergraduate student in one of these departments during the January-June 2026 semester. No additional exclusion criteria were applied. Accordingly, the findings should be interpreted as reflecting the perceptions of undergraduate engineering students at the study institution who participated in this study, rather than those of higher education students in Indonesia more broadly. Because all variables were measured using students' self-reports, the findings represent students' perceptions and experiences rather than direct observations of faculty members or institutional practices.

To obtain the sample, the Google Forms questionnaire was distributed to all undergraduate students enrolled in the Faculty of Engineering during the study period through official faculty communication platforms and student groups. Thus, the study attempted to reach the entire target population within the institution rather than selecting participants through departmental quotas or probability sampling. Participation was entirely voluntary, and 814 students completed the questionnaire fully and accurately, forming the final sample for analysis (Table 1). Because participation depended on students' willingness to respond to the online survey, the final sample was obtained using convenience sampling [11, 17]. Although this non-probability sampling approach may limit the transferability of the findings beyond the studied institution, it was considered appropriate for efficiently collecting data from a large number of eligible participants within the study context. In addition, the cross-sectional design captures students' perceptions at a single point in time, while the use of an online questionnaire may have excluded students with limited internet access.

Table 1 Demographic characteristics of the sample

Variable	Category	Frequency	Percentage
Gender	Male	567	69.66%
	Female	247	30.34%
	Total	814	100%
Department	Electronic Engineering	156	19.17%
	Electrical Engineering	148	18.18%
	Mechanical Engineering	135	16.59%
	Automotive Engineering	128	15.72%
	Civil Engineering	105	12.90%
	Mining Engineering	142	17.44%
	Total	814	100%
Age	< 18 years	84	10.32%
	18–19 years	235	28.87%
	20–21 years	184	22.60%
	22–23 years	192	23.59%
	> 23 years	119	14.62%
	Total	814	100%

3.3 Instrument development

The authors developed the questionnaire used in this study to measure the seven constructs included in the proposed research framework: Faculty Development Support (FDS), Cultural Intelligence (CI), Intercultural Competence (IC), Interculturally Informed Teaching Practices (IITP), Intercultural Student Engagement (ISE), Institutional Support (IS), and Student Learning Outcomes (SLO). Rather than adopting established measurement scales, all questionnaire items were newly developed specifically for this study based on an extensive review of the literature on intercultural education, faculty development, cultural intelligence, intercultural competence, student engagement, institutional support, and learning outcomes in higher education.

The questionnaire development followed a systematic procedure. First, the relevant literature was reviewed to identify the conceptual definitions, principal dimensions, and key indicators associated with each construct. These conceptual indicators were subsequently translated into questionnaire items that reflected the proposed research framework and were written from the perspective of undergraduate engineering students, who constituted the unit of analysis in this study. Consequently, no questionnaire items were directly adopted, adapted, translated, or modified from previously published instruments. Instead, all items were independently developed by the authors to operationalize the conceptual framework proposed in this study. No formal expert review was conducted during the questionnaire development process. Instead, the newly developed items were evaluated through a pilot study to assess their psychometric properties before the main survey. FDS was informed by studies on faculty professional development and intercultural capacity building [19, 43]. CI was informed by the conceptual dimensions discussed by Sternberg et al. [48] and Sousa [46], while IC was informed by Wang and Teo [52] and Xu et al. [54]. IITP drew upon the literature on culturally responsive and inclusive pedagogy [34, 50]. ISE was informed by studies examining student participation in intercultural learning activities [1, 31]. IS was informed by the literature on organizational support for intercultural education [9, 32], whereas SLO were informed by studies on intercultural learning and educational achievement [8, 14].

Following item development, a pilot study with 51 undergraduate engineering students was conducted to assess the instrument's validity and reliability prior to the main survey. The pilot data were analyzed using SPSS. Construct validity was assessed through Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) as the extraction method [2]. The factor loadings ranged from 0.638 to 0.949, exceeding the recommended threshold of 0.50, indicating satisfactory construct validity. All items were loaded onto their intended constructs and were therefore retained for the main survey. Internal consistency reliability was assessed separately for each construct using Cronbach's Alpha [15]. The coefficients were 0.761 for FDS, 0.814 for CI, 0.847 for IC, 0.825 for IITP, 0.798 for ISE, 0.829 for IS, and 0.833 for SLO, indicating satisfactory internal consistency across all constructs. Based on these results, the instrument demonstrated acceptable psychometric properties and was considered suitable for full-scale data collection. Consequently, no substantial revisions were required before administering the main survey. All items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The complete set of questionnaire items used to measure FDS, CI, IC, IITP, ISE, IS, and SLO is presented in Table 2.

Table 2 Indicators for measuring research variables

Variable	Questionnaire item
Faculty Development Support	FDS1: Lecturers can integrate intercultural learning materials in class.
	FDS2: Lecturers often provide training or workshops related to intercultural learning.
	FDS3: Lecturers help me in developing cross-cultural understanding.
	FDS4: Lecturers play an important role in supporting the development of my intercultural skills.
Cultural Intelligence	CI1: I can adjust my behavior when in cross-cultural situations.
	CI2: I make an effort to learn more about other cultures.
	CI3: I effectively work with individuals from different cultures in group assignments.
	CI4: I can identify cultural differences that may affect my social interactions.
Intercultural Competence	IC1: I can communicate effectively with people from different cultural backgrounds.
	IC2: I often consider other cultural perspectives when working in groups.
	IC3: I feel comfortable working with classmates from different cultural backgrounds.
	IC4: I understand the importance of respecting cultural differences in the learning environment.
Interculturally Informed Teaching Practices	IITP1: The instructor uses examples from different cultures in the learning materials.
	IITP2: The instructor effectively encourages discussions involving different cultural perspectives.
	IITP3: The instructor encourages me to think critically about cultural assumptions.
	IITP4: I participate in class activities designed to enhance my cultural understanding.
Intercultural Student Engagement	ISE1: I am involved in class discussions involving intercultural topics.
	ISE2: I participate in campus activities aimed at promoting cross-cultural understanding.
	ISE3: I am involved in work groups or projects involving peers from different cultural backgrounds.
	ISE4: I am interested in learning more about other cultures through campus activities.
Institutional Support	IS1: I am satisfied with the support provided by the institution in developing intercultural skills.
	IS2: Campus programs or policies effectively promote cultural understanding among students.
	IS3: I often have the opportunity to participate in activities on campus that support the development of intercultural skills.
	IS4: The institution is essential in helping me develop cultural awareness.
Student Learning Outcomes	SLO1: I have developed sufficient intercultural skills through my education.
	SLO2: I can apply the cultural knowledge I have learned in real situations.
	SLO3: My education has contributed to my ability to work in multicultural teams.
	SLO4: My cross-cultural understanding has improved during my studies.

3.4 Data analysis

The data collected from the 814 respondents were analyzed using SEM with the assistance of SmartPLS software. SEM was selected for its capability to test complex models that include both direct and indirect effects among multiple variables. Initial data preparation included checking for missing values and outliers and ensuring that the data met the assumptions necessary for SEM. The normality of the data was assessed using skewness and kurtosis values. Data with skewness and kurtosis values outside the recommended range (± 2) were addressed [45], though SEM is relatively robust to deviations from normality when sample sizes are large.

Measurement Model Assessment: This step involves evaluating the reliability and validity of the constructs used in the model. Key criteria include [23]: **Internal Consistency:** Measured using Cronbach's Alpha and Composite Reliability. Cronbach's Alpha should exceed 0.70, and Composite Reliability should exceed 0.70 for each construct to indicate acceptable internal consistency. **Convergent Validity:** This is assessed using Average Variance Extracted (AVE) and outer loading. An AVE value greater than 0.50

indicates that the construct explains more than half of the variance in its indicators. An outer loading value of approximately 0.70 or higher indicates that the indicator has a strong association with its respective construct. Discriminant Validity: Evaluated by comparing the square root of AVE for each construct with the correlations between constructs. The square root of AVE should be greater than the correlations between the construct and other constructs to ensure that each construct is empirically distinct.

Structural Model Assessment: The structural model was tested to explore the relationships between the constructs. This assessment includes the calculation of R^2 values to estimate the proportion of variance explained in the dependent variables, with R^2 categorized as low (0.25), moderate (0.50), and high (0.75) [23]. Additionally, path coefficients were calculated to assess the strength and direction of the hypothesized relationships. The significance of these relationships was assessed using bootstrapping, with p-values below 0.05 and t-values ≥ 1.96 indicating statistical significance at the 5% level [12, 23]. Effect size (f^2) was calculated to evaluate the relative contribution of each predictor construct to the explained variance of the dependent construct, with the following categories: small (0.02), medium (0.15), and large (0.35) [23]. Finally, Q^2 values were analyzed to assess the model's predictive relevance, where a Q^2 value greater than 0 indicates that the model has predictive relevance [23, 27].

4 Results

4.1 Measurement model

The measurement model demonstrated satisfactory reliability and validity, ensuring that all constructs accurately reflect the underlying concepts. Indicators showed strong correlations with their respective constructs, and discriminant validity confirmed that each construct is distinct from the others (detailed Tables are provided in Appendix Tables 7 and 8).

4.2 Structural model

The structural model was evaluated to examine the explanatory power of the hypothesized relationships, as reflected in the R^2 values, which indicate the proportion of variance explained by the model for each dependent variable (Table 3). Notably, interculturally informed teaching practices (IITP) and student learning outcomes (SLO) demonstrated the highest explanatory power, indicating that the proposed model adequately explains the variance associated with key faculty- and student-related outcomes.

Hypothesis testing results (Table 4) confirm that all proposed direct and mediated paths are significant, with t-values exceeding the critical threshold and p-values well below 0.05. These findings indicate strong support for the theoretical framework.

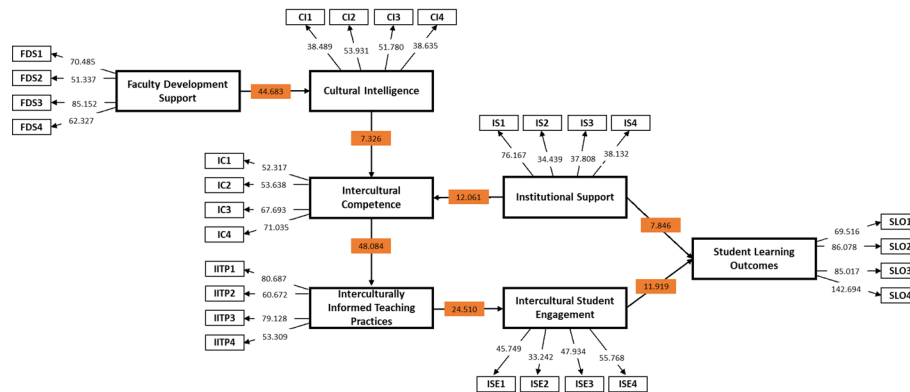
The bootstrapped structural model (Fig. 2) highlights the direct and indirect associations among the constructs examined in this study. FDS was positively associated with

Table 3 R-squared values

Dependent variable	R^2 values
Cultural Intelligence	0.553
Intercultural Competence	0.598
Interculturally Informed Teaching Practices	0.638
Intercultural Student Engagement	0.390
Student Learning Outcomes	0.637

Table 4 Hypothesis testing results

Hypothesis	Path coefficient	t-value	p-value	Supported
FDS → CI	0.744	41.983	<0.001	Yes
CI → IC	0.331	7.579	<0.001	Yes
IC → IITP	0.799	42.925	<0.001	Yes
IITP → ISE	0.625	24.163	<0.001	Yes
ISE → SLO	0.503	12.272	<0.001	Yes
IS → IC	0.500	12.145	<0.001	Yes
IS → SLO	0.345	7.897	<0.001	Yes
FDS → CI → IC	0.246	7.562	<0.001	Yes
CI → IC → IITP	0.264	7.736	<0.001	Yes
IC → IITP → ISE	0.499	17.517	<0.001	Yes
IITP → ISE → SLO	0.314	10.210	<0.001	Yes
FDS → CI → IC → IITP → ISE → SLO	0.062	6.129	<0.001	Yes
IS → IC → IITP → ISE → SLO	0.126	6.777	<0.001	Yes

**Fig. 2** Bootstrapping results of structural model**Table 5** Effect size (f^2)

Path	Effect size (f^2)
FDS → CI	1.239
CI → IC	0.131
IC → IITP	1.764
IITP → ISE	0.640
ISE → SLO	0.293
IS → IC	0.298
IS → SLO	0.138

CI, which in turn was associated with IC and students' perceptions of IITP. These perceived teaching practices were positively related to ISE, which in turn was positively associated with SLO. IS demonstrated significant direct and indirect associations with IC and SLO, indicating that students' perceptions of institutional support are related to their intercultural learning experiences and perceived educational outcomes.

4.3 Effect size (f^2) and predictive relevance (Q^2)

The effect size analysis (Table 5) reveals that FDS has a substantial effect on CI ($f^2 = 1.239$). At the same time, IC shows a large effect size relative to IITP ($f^2 = 1.764$), underscoring the importance of faculty development support and intercultural competence within the proposed model of culturally responsive teaching practices. IITP also

demonstrates a significant effect size with respect to ISE ($f^2 = 0.640$), indicating a strong association between perceived inclusive pedagogical strategies and students' intercultural engagement. Medium effect sizes are observed for other structural paths, indicating meaningful contributions of the respective predictors to explaining variance across the model.

Predictive relevance (Q^2) values (Table 6) indicate that the proposed model demonstrates adequate predictive relevance within the PLS-SEM framework across all endogenous constructs. Among these constructs, SLO and IITP exhibited the highest Q^2 values, indicating comparatively greater predictive relevance within the estimated model. These findings indicate that the proposed framework has acceptable predictive relevance within the PLS-SEM model and adequately represents the observed pattern of associations among the measured variables. The Q^2 results should not be interpreted as evidence of real-world forecasting performance beyond the present dataset.

5 Discussion

The present study examined how institutional and pedagogical factors interact to shape intercultural teaching practices and student learning outcomes in higher education. The present study examined how undergraduate engineering students perceived the relationships among FDS, CI, IC, IITP, ISE, IS, and SLO. By modeling these relationships from students' perspectives, the findings provide a more integrated understanding of how institutional support, faculty practices, and students' intercultural competencies are associated with intercultural teaching and learning processes. One of the most salient findings of this study is that undergraduate engineering students who perceived stronger FDS also reported higher levels of CI. This finding suggests that students who perceive greater institutional investment in faculty development also tend to perceive themselves as possessing stronger intercultural capabilities. Although FDS was evaluated from students' perspectives rather than through direct assessments of faculty members, the results indicate that students associate supportive faculty development environments with their own intercultural development. This result underscores the importance of institutional investment in professional development as a foundational mechanism for cultivating intercultural awareness in academic staff [20]. In increasingly internationalized and culturally diverse classrooms, faculty members are expected to navigate complex cultural interactions and adapt their pedagogical approaches accordingly. The findings suggest that when institutions provide structured training, resources, and opportunities for professional learning, faculty members are more likely to develop the cognitive, motivational, and behavioral dimensions of cultural intelligence required to engage effectively with diverse student populations [38]. It reinforces previous scholarship emphasizing that intercultural capability is not solely an individual attribute but

Table 6 Predictive relevance (Q^2)

Dependent variable	Q^2 value
Cultural Intelligence	0.339
Intercultural Competence	0.408
Intercultural Student Engagement	0.230
Interculturally Informed Teaching Practices	0.451
Student Learning Outcomes	0.496

is significantly shaped by organizational support and professional learning environments [25, 54].

The findings further indicate that students who reported higher CI also reported stronger IC. This relationship suggests that students' ability to understand and adapt to cultural differences is closely associated with their perceived ability to communicate and interact effectively across culturally diverse contexts [53]. Cultural intelligence is associated with educators' ability to recognize cultural differences and interpret cross-cultural interactions more accurately, while intercultural competence reflects the capacity to apply this understanding in meaningful pedagogical and interpersonal engagement [46, 54]. In higher education settings characterized by increasing cultural diversity, these competencies are considered important components of inclusive learning environments and are associated with students' perceptions of equitable participation.

Another important finding is the strong association between students' IC and their perceptions of IITP. Students who reported stronger intercultural competence also tended to perceive greater implementation of culturally responsive teaching practices within their classrooms [40, 50]. One possible explanation is that students with stronger intercultural competencies may be more aware of, and responsive to, instructional practices that value cultural diversity and inclusion.

Students who perceived higher levels of IITP also reported greater ISE. This finding suggests that, from students' perspectives, culturally inclusive teaching practices are associated with greater participation in classroom discussions, collaborative learning activities, and intercultural interactions. When teaching strategies reflect cultural inclusivity and recognize diverse perspectives, students may be more likely to feel represented and valued within the learning environment [35]. his sense of inclusion is associated with deeper participation in classroom discussions, collaborative learning activities, and intercultural dialogue. The findings therefore reinforce the argument that pedagogical design is an important factor in student engagement, particularly in culturally diverse learning contexts [3, 37]. Interculturally responsive teaching practices are also associated with greater opportunities for students to develop intercultural understanding through active participation. The positive relationship between ISE and SLO further highlights the educational relevance of culturally inclusive pedagogies. Students who actively engage in intercultural learning experiences tend to report higher levels of academic achievement and deeper conceptual understanding. This finding suggests that intercultural engagement may represent an important pathway through which culturally responsive teaching practices are associated with educational outcomes [14, 47]. In this sense, student engagement may serve as a mediating process that reflects the relationship among faculty-related perceptions, pedagogical practices, and learning outcomes.

The findings further indicate that students who perceived stronger IS also reported higher levels of IC and SLO. This suggests that students who view their institution as supportive of intercultural learning tend to report higher levels of intercultural competence and more positive educational outcomes. When institutions actively support intercultural initiatives through funding, professional development opportunities, or policy frameworks, faculty members are more likely to adopt pedagogical approaches that are recognized as supportive of intercultural learning processes [5]. These findings reinforce the notion that educational innovation in intercultural teaching is closely associated with broader institutional structures rather than relying solely on individual faculty efforts

[16, 44]. Beyond these direct relationships, the study also reveals several important indirect pathways that highlight the complexity of intercultural teaching and learning processes in higher education. The sequential mediation analysis suggests that students' perceived FDS is indirectly associated with SLO through CI, IC, perceived ITP, and ISE. This finding indicates that students who perceive stronger faculty development support also tend to report higher levels of intercultural competence, greater perceptions of interculturally informed teaching practices, stronger intercultural engagement, and more positive learning outcomes. Because all variables were measured from students' perspectives, these pathways should be interpreted as associations among students' perceptions and self-reported experiences rather than direct causal mechanisms operating at the faculty or institutional level.

This finding provides further insight into ongoing discussions in higher education research regarding the mechanisms through which institutional initiatives are associated with educational outcomes. While universities often invest in faculty development programs with the aim of supporting teaching quality and professional development, the pathways by which these initiatives relate to student outcomes remain poorly understood. The results of this study suggest that faculty development programs are educationally relevant when students perceive them as associated with faculty competencies that support inclusive and interculturally responsive teaching practices. Taken together, the findings highlight the importance of adopting a systemic perspective when designing institutional strategies for intercultural education. Effective intercultural teaching and learning environments may be associated with the alignment of institutional support, faculty development initiatives, pedagogical innovation, and student engagement processes [41, 51]. Institutions that prioritize the development of intercultural capability across organizational, faculty, and classroom contexts may be more likely to provide learning environments that students perceive as supportive of academic achievement and intercultural understanding [30, 35, 42].

From a higher education innovation perspective, this study extends the growing literature on culturally responsive teaching in globally connected universities. As student populations become increasingly diverse and international mobility continues to reshape the higher education landscape, universities face growing demands to develop teaching approaches that reflect cultural inclusivity and global awareness. The present findings indicate that students' perceptions of faculty intercultural capacity are associated with more supportive intercultural learning environments. Furthermore, institutional investment in faculty development and support structures may create conditions conducive to implementing innovative teaching practices, which, in this study, were positively associated with student engagement and learning outcomes.

5.1 Theoretical contributions

This study makes several theoretical contributions to the literature on intercultural education in higher education. First, it proposes an integrated framework that brings together faculty development support, cultural intelligence, intercultural competence, interculturally informed teaching practices, intercultural student engagement, institutional support, and student learning outcomes within a single explanatory model. While previous studies have often examined these constructs independently or in limited combinations, the present study provides empirical evidence for the proposed pattern of

associations among these constructs from the perspective of undergraduate engineering students. Second, the study contributes to the theoretical understanding of intercultural education by highlighting Faculty Development Support and Institutional Support as important contextual factors associated with students' intercultural competencies, engagement, and learning outcomes. This perspective extends previous research, which has predominantly emphasized individual competencies, by incorporating institutional and educational context into a single conceptual framework.

Third, rather than examining cultural intelligence, intercultural competence, interculturally informed teaching practices, and intercultural student engagement as separate constructs, the proposed framework examines how these constructs are sequentially associated within a single model. This integrated perspective provides a more comprehensive conceptual understanding of the relationships among institutional support, faculty-related support, intercultural competencies, teaching practices, student engagement, and students' learning outcomes. The study also extends the literature by examining the proposed framework in the context of undergraduate engineering education in Indonesia, a context that remains underrepresented in existing research on intercultural education. This contextual evidence broadens the empirical scope of the literature. It provides a foundation for future comparative, longitudinal, and multi-institutional studies further to examine the proposed framework across different higher education settings.

5.2 Practical implications for higher education

Although the findings provide useful guidance for higher education institutions, the practical implications should be interpreted within the context of this study. Because the proposed framework was developed from undergraduate engineering students' perceptions within a single public university in Indonesia, the recommendations are most directly applicable to similar institutional and disciplinary settings. Higher education institutions operating in different cultural, organizational, or disciplinary contexts may need to adapt these recommendations according to their own educational environments and institutional priorities. The findings of this study offer several practical implications for higher education institutions seeking to develop more interculturally responsive teaching and learning environments. First, the findings suggest that universities should prioritize faculty development programs that enhance lecturers' capacity to support intercultural learning. Because students who perceived stronger FDS also reported higher levels of CI and IC, investing in professional development initiatives that incorporate intercultural training, reflective learning activities, and cross-cultural pedagogical strategies may be associated with more supportive learning environments from students' perspectives. Second, universities should continue to support the implementation of IITP through curriculum development, teaching resources, and institutional incentives. The present findings indicate that students who perceived greater implementation of interculturally informed teaching practices also reported higher intercultural engagement and learning outcomes, highlighting the importance of culturally inclusive learning environments.

Third, the study highlights the importance of IS as perceived by students. Students who reported stronger IS also tended to report higher IC and SLO, suggesting that visible institutional commitment to intercultural education is associated with more positive

educational experiences among students. Universities should develop institutional policies and strategic frameworks to support the development of intercultural competence among faculty members. It includes allocating resources for professional development, supporting collaborative teaching initiatives, and embedding intercultural learning objectives within institutional teaching and learning strategies. Finally, higher education institutions should recognize intercultural student engagement as an important component of students' learning experiences. Encouraging participation in culturally diverse learning activities, collaborative projects, and internationalized curricula may be associated with stronger students' perceptions of intercultural competencies and learning outcomes. Collectively, these findings suggest that aligning faculty development initiatives, institutional support, and inclusive teaching practices is consistent with creating learning environments that students perceive as more supportive of intercultural development.

5.3 Limitations and future research

Several limitations should be considered when interpreting the findings of this study. First, this study was conducted within a single public university in Indonesia and focused exclusively on undergraduate engineering students. Consequently, the findings reflect students' perceptions within a specific institutional, disciplinary, and national context. They therefore should not be generalized to other universities, academic disciplines, educational levels, or countries without appropriate caution. Future research should examine the proposed framework across multiple institutions, disciplines, and cultural contexts to determine whether the observed associations remain consistent under different educational conditions. Second, the study employed a cross-sectional research design, which limits the ability to examine how intercultural competence, teaching practices, and student engagement develop over time. Because intercultural capability is a dynamic process that may evolve through educational experiences and institutional interventions, longitudinal studies are needed to investigate the stability and development of these relationships across different stages of students' academic journeys. Third, the study relied exclusively on students' self-reported data, which may be influenced by social desirability bias, common method bias, or subjective interpretations of their educational experiences. The findings represent students' perceptions rather than objective evaluations of faculty practices or institutional performance. Future research could incorporate multiple data sources, including faculty assessments, classroom observations, institutional records, and mixed-methods approaches, to examine the proposed relationships from multiple perspectives.

6 Conclusion

This study examined the relationships among FDS, CI, IC, IITP, ISE, IS, and SLO from the perspective of undergraduate engineering students in Indonesia. The findings provide empirical support for the proposed framework by demonstrating significant associations among students' perceived FDS, perceived institutional support, cultural intelligence, intercultural competence, perceived interculturally informed teaching practices, intercultural student engagement, and student learning outcomes. The results suggest that undergraduate engineering students who perceived stronger FDS and IS also reported higher levels of CI, IC, perceived IITP, ISE, and SLO. These findings indicate

that students' perceptions of supportive institutional and instructional environments are positively associated with their self-reported intercultural competencies, engagement, and learning outcomes. Because this study was conducted within a single public university and focused exclusively on undergraduate engineering students in Indonesia, the findings should be interpreted within this specific institutional and disciplinary context. They should not be generalized to other higher education settings without caution. Furthermore, the use of convenience sampling, students' self-reported measures, and a cross-sectional research design limits causal interpretation. It may not fully capture changes in intercultural competence and learning experiences over time. Nevertheless, the proposed framework provides valuable insights into the associations among students' perceptions of institutional support, faculty practices, intercultural competencies, engagement, and learning outcomes. It also provides a useful foundation for future multi-institutional, longitudinal, and multi-source investigations to further validate and extend the proposed model across diverse higher education contexts.

Appendix

See Tables 7 and 8.

Table 7 Measurement model assessment – outer loadings, reliability, validity, and normality indicators

Construct	Indicator	Outer loadings	AVE	Cronbach's alpha	Composite reliability	Skewness	Kurtosis
Faculty Development Support	FDS1	0.869	0.720	0.870	0.912	0.193	-1.059
	FDS2	0.818				1.404	-1.479
	FDS3	0.862				-1.119	-0.640
	FDS4	0.845				0.925	-1.303
Cultural Intelligence	CI1	0.754	0.624	0.798	0.869	0.562	-1.184
	CI2	0.829				0.725	-1.282
	CI3	0.813				0.825	-1.456
	CI4	0.760				0.447	-1.439
Intercultural Competence	IC1	0.825	0.689	0.850	0.899	0.795	-1.405
	IC2	0.815				1.188	-1.343
	IC3	0.829				-0.986	-0.769
	IC4	0.851				0.035	-1.047
Interculturally Informed Teaching Practices	IITP1	0.871	0.712	0.865	0.908	0.161	-1.168
	IITP2	0.817				0.780	-1.091
	IITP3	0.869				0.037	-1.260
	IITP4	0.818				0.397	-1.347
Intercultural Student Engagement	ISE1	0.794	0.618	0.798	0.866	-0.097	-1.105
	ISE2	0.768				0.897	-1.462
	ISE3	0.791				1.263	-1.482
	ISE4	0.792				-1.036	-0.728
Institutional Support	IS1	0.838	0.614	0.791	0.864	0.007	-0.972
	IS2	0.751				1.140	-1.548
	IS3	0.762				-0.285	-1.118
	IS4	0.780				0.464	-1.206
Student Learning Outcomes	SLO1	0.864	0.785	0.908	0.936	0.143	-1.141
	SLO2	0.886				-0.048	-1.102
	SLO3	0.872				0.489	-1.342
	SLO4	0.921				0.008	-1.005

Table 8 Discriminant validity assessment using fornell-larcker criterion

	CI	FDS	IS	IC	ISE	IITP	SLO
CI	0.790						
FDS	0.744	0.849					
IS	0.722	0.691	0.783				
IC	0.692	0.556	0.739	0.830			
ISE	0.737	0.597	0.762	0.753	0.786		
IITP	0.566	0.459	0.756	0.799	0.625	0.844	
SLO	0.611	0.489	0.728	0.734	0.766	0.744	0.886

Note: Bold values represent the square roots of the average variance extracted (AVE), which are compared with the inter-construct correlations to assess discriminant validity using the Fornell–Larcker criterion

Author contributions

Muhammad Husin: Conceptualization, Methodology, Resources, Data curation, Software, Formal analysis, Investigation, Writing – original draft. Shahab Ahmad Almaaytah: Methodology, Resources, Formal analysis, Validation, Writing – original draft, Writing – review and editing. Abdullateef Abdullahi Ibrahim: Methodology, Formal analysis, Writing – review and editing. Abdinasir Ismael Hashi: Methodology, Validation, Writing – review and editing. Omenyo Laban: Methodology, Formal analysis, Validation, Writing – review and editing.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study involved a minimal-risk, anonymous educational survey of undergraduate engineering students. No medical interventions, biological samples, vulnerable populations, or personally identifiable or sensitive personal information were involved. At the time the study was conducted, no formal ethics committee review procedure was required for this type of anonymous educational survey at the authors’ institution. Consequently, no ethics approval, ethics approval number, waiver number, reference code, or waiver date was issued. Before accessing the questionnaire, participants were provided with an information page in Google Forms explaining the purpose of the study, the voluntary nature of participation, the anonymous handling of responses, and their right to discontinue participation at any time before submitting the questionnaire. Participants provided informed consent electronically by voluntarily proceeding to complete and submit the Google Forms questionnaire.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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