ORIGINAL ARTICLE

Volume 18 No. 3 2026

DOI: 10.21315/eimj2026.18.3.15

ARTICLE INFO

Submitted: 31-07-2025
Accepted: 20-04-2026
Online: 30-09-2026

Fostering Medical Students' Interprofessional Socialisation and Identity Through Longitudinal Interprofessional Education: An Observational Study Using Propensity Score Matching

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To cite this article: Hermasari BK, Rahayu GR, Pamungkasari EP. Fostering medical students' interprofessional socialisation and identity through longitudinal interprofessional education: an observational study using propensity score matching. Education in Medicine Journal. 2026;18(3): 219–235. https://doi.org/10.21315/eimj2026.18.3.15

To link to this article: https://doi.org/10.21315/eimj2026.18.3.15

ABSTRACT

The implementation of curriculum-integrated, longitudinal interprofessional education (IPE) is often regarded as positive, but evidence supporting its long-term impact compared to non-longitudinal models is limited. This study aimed to examine the effect of a sustained, curriculum-integrated longitudinal IPE programme on medical students' interprofessional socialisation (IPS) and interprofessional identity (IPI) development compared to a concentrated non-longitudinal programme. A non-randomised observational study utilising propensity score matching was conducted across two Indonesian medical schools: one implementing a longitudinal IPE programme and the other a non-longitudinal programme. Cross-sectional data were collected from students at the end of semesters 2, 4, and 6. IPS and IPI were measured using the Interprofessional Socialisation and Valuing Scale, and the Extended Professional Identity Scale, respectively. Among a total of 344 student participants, those in the longitudinal IPE group demonstrated significantly higher IPS scores (vs the non-longitudinal group), with the difference being most pronounced in semester 6 (Cohen's d = 0.54; $p < 0.001$). Similarly, IPI scores were significantly higher in the longitudinal IPE group in semester 6 (Cohen's d = 0.31; $p < 0.05$). Longitudinal IPE and positive perceptions of interdisciplinary learning were also significant predictors of outcomes, with IPS emerging as a strong independent predictor of IPI ($\beta = 0.35$, $p < 0.001$), with the final model explaining 54% of the variance ($R^2 = 0.54$). The findings indicate that medical students engaged in sustained, longitudinal IPE programmes develop stronger IPS and IPI than those in concentrated, non-longitudinal programmes, with the positive effect strengthening in later study years.

Keywords: *Interprofessional education, Longitudinal, Identity, Socialisation, Medical students*

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INTRODUCTION

Effective interprofessional collaboration (IPC) is crucial for modern healthcare systems as it leads to substantially improved health outcomes, particularly for patients with chronic and complex health conditions, while simultaneously benefiting healthcare workers (1,2). To prepare future health professionals for collaborative practice, the World Health Organization and various international accreditation bodies have advocated interprofessional education (IPE) (2). The primary goals of IPE are to foster strong relationships, increase mutual understanding, optimise interprofessional skills among students, and ultimately enhance patient safety and care quality (2).

However, the educational environment presents significant barriers to the achievement of true interprofessionalism. During their training, students in the healthcare field undergo a process of educational socialisation that is often structured around a profession-specific model, strongly reinforcing disciplinary isolation and leading to the development of a 'uniprofessional identity' (3). This phenomenon is supported by social identity theory, which posits that deep identification with one's professional group can foster in-group favouritism and negative outgroup bias toward other disciplines (4). This lack of agreement and cohesion between individual professional identities is a major barrier to effective IPC practices (5,6). Consequently, students in the healthcare field require engagement with optimised interprofessional socialisation (IPS) processes through participation in collaborative teams to overcome these barriers (7,8). The goal of IPS is to expand the existing professional identity into a shared understanding and reducing discrimination and distrust, which are crucial for the formation of an interprofessional identity (IPI) (8–10).

The development of a robust IPI through IPS is challenging for medical students. Research has consistently shown that medical students tend to exhibit lower perceptions of IPC, readiness for interprofessional learning, and place less value on interprofessional clinical education than students from other healthcare professions (11–13). This challenge stems from a deeply ingrained hierarchical socialisation, a strong emphasis on professional autonomy, and distinct clinical rotations that often isolate them from collaborative team dynamics (14–16). Meanwhile, the success of IPE interventions in fostering IPI is significantly moderated by students' initial perceptions of and attitudes towards interdisciplinary learning (17). Positive perceptions and beliefs about interdisciplinary learning can act as catalysts, enhancing the effectiveness of IPS processes and accelerating IPI formation, whereas negative perceptions can impede engagement and limit collaborative outcomes (17).

To counteract professionalisation barriers and address the specific challenges faced by medical students, an appropriate IPE strategy is necessary. Research shows that forming an IPI requires a sustained approach that gradually eliminates misperceptions and prejudices (16,18). Considering these remarks, there are strong logical reasons to hold that longitudinal IPE, implemented throughout the curriculum, may be an excellent solution to support IPI among students. Indeed, repeated interprofessional participation over a long period has been shown to protect against a decline in collaborative skills and attitudes (19). Furthermore, IPE guidance from organisations such as the Health Professions Accreditors Collaborative emphasises the need for meticulously structured, longitudinal design plans (i.e., overing the entire curriculum with content adjusted to the educational level) to fulfil outcome-based objectives (20). This sustained approach facilitates the gradual refinement of professional identity and the understanding of teamwork importance (21).

Despite this rationale, few studies have examined the effect of a truly longitudinal IPE approach implemented throughout the curriculum (from entry to graduation) on IPS and IPI development, especially in multi-institutional settings or in comparative studies with non-longitudinal IPE (18,22,23). Given the unique predisposition of medical students toward uniprofessionalism and the critical role of their perceptions in the learning process, it is essential to investigate the efficacy of the most robust IPE design available in fostering IPI. However, comparative studies across different institutions are inherently prone to selection bias as students are not randomly assigned to the interventions. Preexisting differences in student characteristics, such as age, sex, or prior teamwork experience, can also act as confounding variables, hindering attribution of the observed outcomes solely to the curricular model. Consequently, rigorous methodological approaches such as propensity score matching (PSM) are essential in related observational settings to balance study groups and reduce the effects of confounding factors, thereby providing more accurate estimates of the programme's true effect. Therefore, this study aimed to examine the effect of longitudinal IPE implemented throughout the curriculum on the development of IPS and IPI among medical students.

METHODS

Study Design

In this non-randomised observational study, the longitudinal IPE was implemented throughout the curriculum, from the time medical students enter the undergraduate programme until they graduate. The study tested three hypotheses: Hypothesis 1, longitudinal IPE positively influences IPS and IPI; Hypothesis 2, students exposed to longitudinal IPE score higher than those exposed to non-longitudinal IPE; Hypothesis 3, among longitudinal IPE participants, senior students score higher than junior students.

Intervention

The intervention was exposure to longitudinal IPE in School A, which was contrasted with the non-longitudinal IPE experience in School B. Table 1 presents a detailed comparison of key aspects of the programmes.

Setting and Participants

Although the IPE programmes implemented at both institutions were inherently multidisciplinary (involving collaborative interactions with students from the Nursing, Nutrition, Pharmacy, and Midwifery programmes), the target population, data collection, and inclusion criteria for this study were strictly limited to undergraduate medical students. This exclusive focus was intentionally chosen to closely examine the trajectory of interprofessional socialisation and identity formation within the context of medical education, which has historically been characterised by strong uniprofessional socialisation.

Table 1: Comparison of key aspects of IPE implementation in two medical schools

Aspect	School A (Longitudinal IPE)	School B (Non-longitudinal IPE)
Duration of IPE	7 semesters: Semester 1 through Semester 7	2 semesters (Semesters 4 and 5)
Credit semester unit (CSU)	1 CSU per semester (total 7 CSUs)	3 CSUs/semester (total 6 CSUs)
Frequencies of team meetings/semester	5–6 team meetings	10–13 team meetings
Learning model	Team-based project	Team-based project
Learning tasks	Year I: Team building Introduction to partner families Year II: Health assessment of partner families Health education and empowerment programmes for partner families based on assessment results Education of partner families on initial management of emergency cases Year III: Continuing education and empowerment programmes related to the health of partner families Development of health education and empowerment programmes for community Education about initial steps during the occurrence of natural disasters Year IV: Observing and collaborating on health in real practice (internship sites)	Team building Health assessment of partner families Family health education programme Community health education programme
Details of learning activities	Team-based projects: Collaborative student learning activities in the community. During community learning activities, students receive lectures from experts and tutorials or guidance from field supervisors.	Team-based projects: collaborative student learning activities in the community. Students receive lectures from experts before going into the community. During community learning activities, students receive lectures from experts, collaborative case-based learning, and tutorials or guidance from field supervisors.
Study programmes included	Bachelor of Medicine Bachelor of Nursing Bachelor of Nutrition	Bachelor of Medicine Bachelor of Pharmacy Bachelor in Midwifery

The learning strategies employed included collaborative problem-based learning, community diagnosis, and joint family management projects, as detailed in Table 1. The schools were selected based on the following specific criteria regarding IPE:

a. School A: The selection was based on the status of being part of the few medical schools in Indonesia that integrated longitudinal IPE into the seven-semester curriculum, in line with the recommendations of the Health Profession Accreditors

Collaboration 2019. This framework emphasises intentionally designed sequential IPE experiences embedded within the curriculum, spanning the entire duration of the programme, with content and instructional formats tailored to student-level and outcome-based objectives. This method allows the provision of repeated interprofessional learning opportunities throughout the curriculum, with increasing depth and breadth based on student progression.

b. School B: The selection of School B aimed at achieving a meaningful comparison group with the intervention group based on several factors, including (i) an excellent accreditation rating confirming high educational standards and similarities to that of School A; (ii) implementation of a non-longitudinal IPE programme, offering a contrasting method to School A; (iii) featuring an IPE model that shares a similar community-based learning method with that of School A; and (iv) the programme involves the same three healthcare professions as in School A. A preliminary search of recent publications, medical school websites, and interviews with IPE management units confirmed that only a limited number of medical schools are implementing longitudinal IPE, and identified School B as a suitable comparison for this study.

The duration of the undergraduate curriculum in both medical schools was the same at seven semesters. The participants were medical students from both schools, including those from semesters 2, 4, and 6 from School A and those from semesters 4 and 6 (i.e., there is no presence of students from semester 2 because students in this institution are exposed to the IPE programme only in semesters 4 and 5) from School B.

The study's sample size was determined a priori to ensure adequate statistical power to detect differences in mean socialisation and IPI scores between the two IPE models. Owing to the absence of comparable prior research, we assumed a medium effect size (Cohen's $d = 0.5$), a significance level (α) of 0.05 (two-tailed test), a statistical power ($1-\beta$) of 0.80, and assumed equal group sizes (1:1 ratio) and equal variances; calculations indicated a minimum of 64 participants per group, resulting in a minimum total sample of 128 participants. The sample size of this study met the minimum sample size.

Propensity Score Matching (PSM)

In observational studies where students cannot be randomly assigned to different curricula, directly comparing outcomes across institutions can be misleading due to pre-existing student differences (selection bias). To address this issue, we employed PSM as a statistical technique to artificially mimic a randomised controlled trial (24). PSM achieves this by calculating a 'propensity score' for each student, representing their probability of enrolment in a longitudinal IPE programme based on their baseline characteristics. We created highly comparable groups by matching students with similar propensity scores from the different programmes. This matching process focused on balancing confounding variables, such as the semester of study, age, sex, and teamwork experience outside formal IPE (25). Ultimately, this quasi-randomised setup ensures that any observed differences in IPS and IPI outcomes are more confidently attributable to the IPE curriculum model rather than to pre-existing student variations. This helps reduce the potential for selection bias inherent in the non-randomised study design (17), and diminish the potential confounding factors in the relationship between the IPE model, IPS, and IPI in order to enhance the internal validity of the study and facilitate a more precise estimation (24,25). Using the nearest neighbour matching technique, PSM was carried out using Stata with the IPI and IPS scores of students in both groups from semesters 4 and 6. Specifically, the nearest neighbour

matching algorithm was applied at a 1:1 matching ratio without replacement. This 1:1 ratio was selected to prioritise the closest possible matches and minimise bias, which is highly recommended when the control pool is sufficiently large(24). To analyse the adequacy of the matching ratio and success of the PSM procedure, we evaluated the covariate balance before and after matching, specifically by comparing the distribution of baseline characteristics (semester of study, age, sex, and prior teamwork experience) between both groups. A successful match was defined as the elimination of statistically significant differences ($p > 0.05$) in these covariates (provided in the results section), ensuring that the matched pairs were functionally equivalent before comparing their IPS and IPI outcomes.

Data Collection and Measurements

This study utilised three validated scales to measure IPS, IPI, and perception of interdisciplinary education. IPS was measured using the validated Indonesian version of the Interprofessional Socialization and Valuing Scale (26). This instrument uses a seven-point Likert scale ranging from 1 (not at all) to 7 (to a very great extent). A previous cross-cultural validation study demonstrated its excellent internal consistency, with a Cronbach's alpha of 0.92 and McDonald's Omega of 0.92 for the student cohort. Construct validity was established through confirmatory factor analysis, confirming its unidimensional structure and measurement invariance across health practitioners and students (26). Finally, subsequent pilot testing with 52 medical students confirmed the adequacy of its psychometric properties, with an internal consistency of Cronbach's alpha of 0.813 and all items demonstrating validity ($p < 0.05$).

IPI was assessed using the 12-item Indonesian version of the Extended Professional Identity Scale (27), which measures three dimensions, responded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), as follows: interprofessional belonging, interprofessional commitment, and interprofessional beliefs. Its construct validity has been previously confirmed via confirmatory factor analysis, with factor loadings ranging from 0.59 to 0.86, and five goodness-of-fit indices indicating a sufficient model. The instrument also exhibited strong reliability, with an overall Cronbach's alpha of 0.90, and subscale alphas ranging from 0.82 to 0.87 (27). The reliability in the current study's pilot test remained excellent, with an overall Cronbach's alpha of 0.851.

Lastly, the perception of interdisciplinary education was measured using the Interdisciplinary Education Perception Scale modified by McFadyen et al. (28). The 12-item instrument assessed three domains, namely competency and autonomy, need for cooperation, and perception of cooperation, through a six-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). The Indonesian version utilised in this study was adopted from an adaptation and validation study conducted by Ulung (29), which established the validity ($p < 0.05$) and acceptable reliability of the items for Indonesian healthcare professional students. Pilot testing in this study yielded a very good internal consistency, with an overall Cronbach's alpha of 0.884. This variable was included in this study because several studies have mentioned that it serves as an important moderator variable for IPE outcomes (30–32).

These instruments were administered to all participants at the end of semesters 2, 4, and 6 using Google Forms.

Data Analysis

The assumptions for parametric testing were evaluated prior to conducting the inferential analyses. The normality of the data distribution was confirmed using the Kolmogorov-Smirnov test ($p > 0.05$), while the homogeneity of variances was verified using Levene's test ($p > 0.05$). Following successful PSM, independent samples *t*-tests were used to compare continuous IPS and IPI scores between students in the longitudinal and non-longitudinal programmes. Furthermore, to evaluate the developmental progression of IPS and IPI across three independent student cohorts within the longitudinal programme (semesters 2, 4, and 6), a one-way analysis of variance (ANOVA) was conducted, followed by Bonferroni post-hoc tests for specific group comparisons.

Multiple linear regression analyses were performed to assess the effects of the IPE programmes. A hierarchical multiple linear regression was also conducted to comprehensively evaluate the relationships and potential mediating pathways between the IPE programme model, students' perceptions, IPS, and IPI. The analysis was structured systematically into six steps, as shown below, to examine how the introduction of specific covariates altered the predictive power of the independent variables.

a. Models 1 and 2 (predicting socialisation): These models assigned IPS as the dependent variable. Model 1 tested the baseline main effect of the longitudinal IPE programme on IPS. Model 2 subsequently introduced student perceptions of interdisciplinary education as a covariate to determine whether the programme's effects remained robust after accounting for individual baseline attitudes.

b. Models 3 and 4 (predicting identity directly): These models assigned IPI as the dependent variable without including IPS as a predictor. Model 3 evaluated the direct impact of the longitudinal programme on IPI. Model 4 included student perceptions of interdisciplinary education to observe how these attitudes might moderate or unmask the programme's direct effect on IPI.

c. Models 5 and 6 (testing mediation on identity): These final models examined the mediating role of socialisation by introducing IPS as a predictor of IPI. Model 5 combined the IPE programme and IPS to determine whether socialisation explains the variance in IPI better than the curricular model itself. Finally, Model 6 served as a comprehensive full model, incorporating the IPE programme, perceptions, and IPS, to identify the strongest and most significant independent predictors of IPI formation.

RESULTS

To understand the progression of IPS and IPI within the longitudinal IPE programme, we first examined scores across different semesters within School A. Table 2 presents the mean scores for the Interprofessional Socialisation and Valuing Scale and Extended Professional Identity Scale across semesters 2, 4, and 6, along with the ANOVA and Bonferroni post-hoc test results.

Table 2: Comparison of IPS and IPI scores across semesters in the longitudinal IPE programme (ANOVA with Bonferroni correction)

Variable	Semester 2 (n = 50)	Semester 4 (n = 53)	Semester 6 (n = 94)	η^2 (95% CI)	Post-hoc (Bonferroni)
Interprofessional socialisation					
Overall	48.38 (7.42)	50.53 (5.42)	51.68 (7.37)	0.04* (0.00-0.09)	2 vs. 4: ns; 2 vs. 6: $p < 0.05$*; 4 vs. 6: ns
Value	22.82 (3.47)	23.23 (2.50)	24.09 (3.42)	0.03 (0.00–0.08)	–
Comfort	14.62 (3.12)	15.77 (2.31)	15.80 (3.14)	0.03 (0.00–0.08)	–
Ability	10.94 (1.75)	11.53 (1.72)	11.80 (1.94)	0.04* (0.00–0.09)	2 vs. 4: ns; 2 vs. 6: *$p < 0.05$*; 4 vs. 6: ns
Interprofessional identity					
Overall	48.78 (5.41)	52.66 (5.80)	53.20 (5.85)	0.09*** (0.03–0.17)	2 vs. 4: $p < 0.01$**; 2 vs. 6: $p < 0.001$***; 4 vs. 6: ns
Belonging	16.36 (1.89)	17.58 (2.33)	17.79 (2.28)	0.07*** (0.13–0.14)	2 vs. 4: $p < 0.01$**; 2 vs. 6: $p < 0.001$***; 4 vs. 6: ns
Commitment	15.82 (2.29)	16.98 (2.29)	17.03 (2.44)	0.05** (0.00–0.11)	2 vs. 4: $p < 0.05$*; 2 vs. 6: $p < 0.05$*; 4 vs. 6: ns
Belief	16.60 (2.12)	18.09 (2.02)	18.38 (1.98)	0.12*** (0.04–0.20)	2 vs. 4: $p < 0.001$***; 2 vs. 6: $p < 0.001$***; 4 vs. 6: ns

Notes: Data are presented as mean (standard deviation); ns: non-significant; CI: confidence intervals; Significant *p*-values are shown in starred

A cross-sectional analysis of the longitudinal IPE programme revealed distinct developmental patterns for IPS and IPI across student cohorts. While IPS demonstrated a statistically significant difference ($p = 0.026$), the progression was gradual. Post-hoc comparisons indicated that meaningful improvements were only evident when comparing the most senior cohort (semester 6) to the entry-level cohort (semester 2), driven primarily by the ability subscale. In contrast, IPI exhibited a more robust and immediate differentiation ($p < 0.001$, $\eta^2 = 0.09$), with students in both semesters 4 and 6 scoring significantly higher than those in semester 2 across all subscales. The lack of a significant difference between the semesters 4 and 6 cohorts in identity scores suggests that professional identity, particularly students' beliefs, is established relatively early in the educational continuum and plateaus, whereas socialisation competencies require a longer period of academic exposure to manifest significant development.

Table 3 compares participant characteristics across the two schools before and after PSM. The table shows no significant differences between the characteristics of the two groups. This demonstrated successful matching and enhanced confidence that any observed differences in outcomes were attributable to the IPE intervention rather than to pre-existing group differences.

Table 3: Comparison of characteristics of participants in the two schools before and after PSM

Characteristics	Before			After		
	Longitudinal N (%)	Non-longitudinal N (%)	*p*-value	Longitudinal N (%)	Non-longitudinal N (%)	*p*-value
N	147	302	–	147	147	–
Semester						
4	53 (36.1)	142 (47.0)	0.028	53 (36.1)	53 (36.1)	1.00
6	94 (63.9)	160 (53.0)		94 (63.9)	94 (63.9)	
Age (years) (mean ± SD)	20.63 (0.80)	20.30 (1.03)	< 0.001	20.63 (0.80)	20.61 (0.82)	0.83
Sex						
Male	57 (38.8)	106 (35.1)	0.35	57 (38.8)	56 (38.1)	0.90
Female	90 (61.2)	196 (64.9)		90 (61.2)	91 (61.9)	
Frequency of teamwork outside IPE curriculum for the last six months						
Never	13 (8.8)	67 (22.2)	0.002	13 (8.8)	13 (8.8)	1.00
Sometimes	97 (66.0)	160 (53.0)		97 (66.0)	97 (66.0)	
Often	37 (25.2)	75 (24.8)		37 (25.2)	37 (25.2)	

Notes: Never: no activities for the last six months; Sometimes: one time in the last six months up to 1–2 times in the last 30 days; Often: 1–2 times per week up to everyday

Following successful PSM to ensure group comparability (Table 3), we proceeded with a primary comparison between the longitudinal and non-longitudinal IPE programmes before adjusting for covariates. Figure 1 provides a comprehensive overview of the differences in the overall IPS and IPI scores.

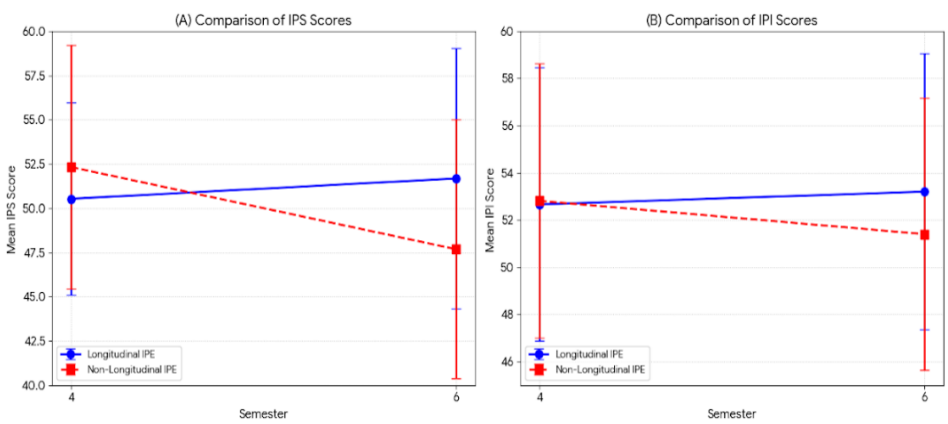

Figure 1: Comparison of IPS and IPI scores between longitudinal and non-longitudinal IPE programmes across semesters 4 and 6.

Figure 1 visually illustrates the distinct temporal trajectories for IPS and IPI scores between the two student groups across semesters 4 and 6. Regarding IPS, the graph reveals a notable crossover interaction: in semester 4, the non-longitudinal group exhibited slightly higher initial scores than their longitudinal counterparts; a significant divergence occurred by semester 6, as the longitudinal group showed continued development, whereas the non-

longitudinal group experienced a marked decline, resulting in a substantial performance gap that favoured sustained exposure. A similar pattern emerges for IPI: while both groups began with negligible differences in identity scores in semester 4, their developmental paths diverged in semester 6, as students exposed to the longitudinal IPE programme demonstrated a sustained increase in professional identity formation, whereas non-longitudinal students showed a decrease over the same period, visually confirming the long-term diminishing effect of concentrated interventions that lack continuous reinforcement.

Table 4 shows the results of the multiple linear regression analysis conducted to determine the effects of the longitudinal IPE programme and of perception of interdisciplinary education on IPS and IPI, and IPS on IPI.

Table 4: The effects of the longitudinal IPE programme and perception of interdisciplinary education on IPS and IPI

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Dependent variable: IPS	Dependent variable: IPS	Dependent variable: IPI	Dependent variable: IPI	Dependent variable: IPI	Dependent variable: IPI
IPE Model						
Longitudinal	1.91* (0.28–3.55)	1.86** (0.48–3.25)	1.09 (−0.24–2.43)	1.04* (0.02–2.08)	0.08 (−0.94–1.11)	0.39 (−0.52–1.31)
Non-longitudinal (base)			Reference			
Perception towards interdisciplinary learning	–	0.51*** (0.42–0.61)	–	0.50*** (0.43–0.57)	–	0.32*** (0.25–0.39)
IPS	–	–	–	–	0.53*** (0.45–0.60)	0.35*** (0.27–0.43)
R^2	0.02	0.29	0.01	0.41	0.42	0.54

Notes: N of observations = 294; Data are presented as coefficient (95% confidence interval); * Significant *p*-values

Models 1 and 2 show the effects of longitudinal IPE programme and perception of interdisciplinary education on IPS. Model 1 indicates that longitudinal learning has a significant positive effect on IPS. The regression coefficient suggests that students who participated in longitudinal learning tended to have an IPS score 1.91 points higher than those who did not. Importantly, Model 2 shows that this effect, now with a coefficient of 1.86, remains significant even when student perception of interdisciplinary education is added to the model. This implies that longitudinal learning has a positive effect on IPS beyond the influence of students' perceptions of interdisciplinary education. Model 2 also shows that the perception of interdisciplinary education has a significant positive effect on IPS with a coefficient of 0.51, implying that a one-unit increase in such perception is associated with a 0.51-point increase in IPS.

Regarding the effects on IPI, Model 3 reveals that the longitudinal IPE programme alone did not show a statistically significant association. However, in Model 4, after controlling for perceptions of interdisciplinary education, the programme's effect becomes significant. This suggests that individual differences in students' attitudes towards interdisciplinary learning may mask the programme's impact. When these perceptions are taken into account, the programme's positive influence on IPI becomes evident.

Finally, Models 5 and 6 show the effects of IPS on IPI. Model 5 shows that IPS has a significant positive effect on IPI: a one-unit increase in IPS is associated with a 0.53-point increase in IPI. Model 6 shows that adding perception of interdisciplinary education to the model maintains the significance of IPS, though the regression coefficient decreases slightly. This suggests that IPS is an important factor determining IPI regardless of perceptions of interdisciplinary education. The R-squared value of 0.54 indicates that Model 6 is the best for explaining IPI variation.

DISCUSSION

This study explored the impact of a longitudinal IPE programme on the development of IPS and IPI among medical students. Overall, our findings supported our hypotheses. Specifically, in line with Hypotheses 1 and 2, the results provide compelling evidence that longitudinal IPE programmes positively influence the formation of IPS and IPI. Students exposed to the sustained longitudinal model ultimately scored significantly higher on both the IPS and IPI than those exposed to the non-longitudinal model, as demonstrated by the widening performance gap in semester 6. Furthermore, supporting Hypothesis 3, our cross-sectional analysis within the longitudinal programme confirmed a developmental progression, as senior students (semester 6) scored significantly higher across the IPS and IPI dimensions than junior students (semester 2). The following sections discuss the mechanisms underlying these outcomes in greater detail.

The most prominent finding supporting Hypotheses 1 and 2 is the significant divergence in IPS and IPI levels by semester 6, in which students exposed to the longitudinal IPE programme outperformed their non-longitudinal counterparts. This outcome aligns with intergroup contact theory (33–35), which posits that the duration of contact is a fundamental factor facilitating qualitative shifts in psychological processes between groups. Indeed, sustained, diverse interactions over an extended period act as protective mechanisms against the erosion of collaborative attitudes, allowing for the development of deeper affective mechanisms such as empathy and trust (36). This continuous reinforcement facilitates gradual social identity transformation, integrating interprofessional values into students' emerging professional self-concepts (37).

An intriguing observation was the lack of a significant difference between the two models in semester 4, with the non-longitudinal group showing slightly higher, although non-significant, scores. This suggests that concentrated IPE interventions may produce a 'novel effect', yielding immediate but transient positive outcomes owing to the initial excitement of collaborative learning (38). However, as students advance, the increasing complexity of clinical responsibilities can undermine these idealised perceptions if they are not continuously reinforced (39,40). The significant gap that emerges by semester 6 highlights that IPS is not a permanent trait acquired after a single exposure, but a dynamic competency requiring continuous 'dosage' for maintenance and deepening as students navigate the 'hidden curriculum' of uniprofessional clinical rotations(41–43).

Supporting Hypothesis 3, the cross-sectional analysis within the longitudinal programme showed that senior students scored higher than junior students. The data reveal distinct developmental patterns, as while IPI (particularly beliefs) appeared to become established relatively early in the educational continuum and plateau, IPS seemed to require a more extended duration of academic exposure to manifest significant development. IPI formation is a complex process influenced by deeply ingrained professional cultures, roles, and

external factors, such as the learning environment and role models (43–46). Indeed, medical students often enter IPE programmes with pre-existing attitudes and professional identities strongly influenced by their specific professional programmes, which can make them initially less responsive to IPI changes than other healthcare professionals (47,48).

While our findings confirmed the hypotheses regarding the curricular model and seniority, our regression models revealed the specific mechanisms driving these outcomes. The finding that the direct effect of the longitudinal IPE programme on IPI became significant only after controlling for students' perceptions of interdisciplinary education is especially insightful, indicating that positive initial attitudes act as powerful moderators or catalysts enhancing the effectiveness of educational interventions. Prior research shows that students who value collaboration are more likely to engage meaningfully with educational interventions, accelerating their IPI formation (7,49,50). Furthermore, the strong and consistent predictive relationship between IPS and IPI underscores socialisation as the primary mediating mechanism of identity formation. Positive collaborative experiences are essential antecedents for the internalisation of shared interprofessional identities (28,44).

Limitations and Practical Implications

Despite rigorous application of PSM to mitigate selection bias, unmeasured confounders, such as individual personality traits or variations in clinical placement quality, may still influence the observed relationships. Additionally, while reliance on self-reported measures introduces potential social desirability bias, several procedural strategies have been employed to mitigate this risk. First, the data collection procedures were designed to reduce evaluation apprehension, as students were explicitly assured of their confidentiality and informed that their responses would have no bearing on their academic grades. Second, the utilisation of rigorously validated, standardised instruments such as the Indonesian Interprofessional Socialisation and Valuing Scale and the Extended Professional Identity Scale provides structured measurement parameters that further help constrain excessive response distortion compared to ad hoc questionnaires. The cross-sectional nature of the data limits the ability to draw definitive causal conclusions regarding individual developmental trajectories. This highlights the need for future studies using a longitudinal design to track the same students over time, validating the results and investigating the long-term effects of longitudinal IPE on collaborative practice behaviours in clinical environments.

For medical students themselves, the implications of developing strong IPS and IPI through longitudinal exposure are profound, particularly as they transition into workplace-based learning during their clinical clerkships. The clinical environment is inherently complex and often characterised by hierarchical pressures that can trigger significant stress and burnout, while a robust IPI can act as a psychological buffer in this context. It equips students with the collaborative communication skills and shared clinical reasoning capacities needed to navigate complex patient care situations as part of a supportive interprofessional team. Consequently, this shared identity can help mitigate the isolation and burnout that medical students frequently experience when strictly adhering to a siloed, uniprofessional identity (51).

For curriculum designers, these findings imply that sporadic or 'one-off' IPE modules are insufficient for long-term impact. Effective IPI formation requires a longitudinal thread running parallel to profession-specific training, as this seems to ensure that interprofessional values are reinforced even as students develop strong uniprofessional identities. Furthermore, educational strategies must explicitly target and foster positive

perceptions of interdisciplinary learning at early stages of tertiary education, as these attitudes significantly condition the curriculum's long-term effectiveness. Future research using longitudinal cohort tracking should validate these developmental patterns and explore the mechanisms of identity formation in diverse healthcare settings.

CONCLUSION

This study provides significant evidence supporting the advantages of a longitudinal IPE programme applied throughout the curriculum for fostering medical students' IPS. Moreover, it demonstrated that the application of this programme, especially in later semesters and supported by positive perceptions of interdisciplinary education, also contributes to the development of stronger IPI. This study adds to the literature as one of the first multi-institutional investigations in Indonesia to use PSM to isolate the effects of a longitudinal IPE programme. The findings confirm that sustained curriculum-integrated IPE programmes are superior to concentrated models in fostering long-term IPS and IPI among medical students. Educators should prioritise longitudinal designs that extend into the clinical years, while future research should employ longitudinal cohort tracking and qualitative methods to elucidate the complex mechanisms underlying identity formation in diverse healthcare settings.

ACKNOWLEDGEMENTS

The authors thank all participants who were willing to participate in this study. This research was funded by the Universitas Sebelas Maret under the research grant Penelitian Disertasi Doktor (PDD-UNS) with reference number 369/UN27.22/PT.01.03/2025.

ETHICAL APPROVAL

Ethical approval for this study was obtained from the Medical and Health Research Ethics Committee (MHREC) Faculty of Medicine, Public Health, and Nursing Universitas Gadjah Mada – Dr. Sardjito General Hospital (No: KE/FK/0205/EC/2024). Informed consent was obtained from all student participants prior to their participation in the study, and they were informed that they had had the right to refuse to participate in the study and that participation would not affect their academic grades.

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