



Assessing Merdeka Curriculum Impact on High School Physical Education Learning Outcomes

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Abstract

Studi Purpose. This study examined the effectiveness of Indonesia's Merdeka Curriculum in Physical Education, Sport, and Health (PESH) by evaluating changes in students' physical, cognitive, and social-emotional learning outcomes from pre-implementation baseline to post-implementation. It also investigated contextual factors influencing successful curriculum implementation across different school environments.

Materials and Methods. A quantitative pre-post evaluative design was employed involving 450 students aged 15–18 years from 15 senior high schools located in urban, suburban, and rural areas of North Sumatra, Indonesia. Participants were selected through proportional stratified sampling to ensure balanced demographic representation. Data were collected at two time points—pre-implementation (baseline) and post-implementation—using four validated instruments: the Physical Competency Assessment Tool (PCAT), Cognitive Assessment Questionnaire (CAQ), Social-Emotional Learning Scale (SELS), and an Implementation Factor Survey. All instruments demonstrated satisfactory reliability (Cronbach's $\alpha = 0.84\text{--}0.93$). Pre-post changes were evaluated using paired analytical methods, while between-group differences were examined using independent-samples t-tests, one-way ANOVA, chi-square tests, and multiple regression analyses.

Results. Significant differences in implementation effectiveness were also identified across school locations and resource levels ($p < .001$). Significant positive changes were observed across all assessed domains following curriculum implementation. Physical competency showed substantial

improvement, with cardiovascular endurance recording the highest increase (18.5%; $d = 0.92$, $p < .001$). Cognitive performance reached a satisfactory level overall, particularly in health literacy (72.5%), although nutrition knowledge remained comparatively lower (68.7%) and varied significantly according to socioeconomic status and school location ($p < .01$). Social-emotional development demonstrated the strongest gains, with communication and leadership skills increasing by 31% ($p < .001$). Teacher preparedness ($R^2 = 0.42$) and resource availability ($R^2 = 0.38$) emerged as the most influential predictors of student achievement. Significant differences in implementation effectiveness were also identified across school locations and resource levels ($p < .001$).

Conclusions. The Merdeka Curriculum contributes positively to holistic student development in PESH by enhancing physical fitness, health-related knowledge, and social-emotional competencies. However, disparities in resources and contextual conditions continue to influence implementation quality, emphasizing the need for equitable educational support, continuous teacher development, and stronger integration of nutrition education.

Keywords: Merdeka Curriculum, Physical Education, Student Learning Outcomes, Curriculum Evaluation, Social-Emotional Learning, Educational Equity.

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Introduction

The Merdeka Curriculum, implemented as a comprehensive educational reform in Indonesia, aspires to establish a more adaptable and responsive educational paradigm that addresses the varied developmental requirements of learners ([Ibnus & Madri, 2020](#)). This educational framework underscores the significance of dynamic, learner-centered methodologies and affords instructors enhanced pedagogical independence within the teaching and learning process ([Januarita et al., 2023](#)). Physical Education, Sport, and Health (PESH) constitute a distinct academic discipline that necessitates focused scrutiny, as curricular engagement compels students to participate in structured athletic activities that simultaneously offer diverse cognitive and motor learning opportunities ([Mastagli et al., 2020](#)). The Merdeka Curriculum specifically emphasizes learner independence, proficiency-oriented pedagogy, and comprehensive growth, thereby reflecting an increasing acknowledgment of the essential role of physical education in the holistic development of students ([Romanova et al., 2023](#); [Corbin, 2020](#)). As this curriculum continues to be implemented across educational institutions, assessing its efficacy within the specific context of physical education, athletics, and health becomes imperative ([Gazali et al., 2022](#)).

The constructivist learning theory has progressively informed the methodological framework of the Merdeka Curriculum within the realm of physical education ([Irmansyah et al., 2021](#)). This student-centric theoretical framework accentuates the dynamic construction of knowledge, wherein learners assume a pivotal role in the educational process through active investigation, trial, and formulation of their own understanding of physical principles and competencies ([Hidayat & Sujarwo, 2022](#); [Suherman, 2018](#)). This transition toward engaged, student-centered pedagogy corresponds with the curriculum's fundamental objectives of fostering autonomy, competency-oriented growth, and comprehensive well-being ([Mentzer et al., 2022](#)). Empirical investigations have begun to elucidate the effects of the Merdeka Curriculum on educational outcomes in physical education, athletics, and health ([Maheswari et al., 2023](#); [Sari & Sutapa, 2020](#); [Siregar et al., 2022](#)). Several studies have examined educators'

capacity to establish learning objectives and construct instructional modules within this framework ([Gazali et al., 2022](#); [Ndari et al., 2023](#)), revealing that the curriculum's emphasis on adaptability and learner-centric pedagogy presents significant implementation obstacles for teachers who encounter difficulties reconciling their teaching methodologies with the curriculum's fundamental objectives ([Pusporini et al., 2023](#); [Sari et al., 2023](#); [Aji, 2023](#)). These findings highlight the necessity for extensive educator preparation and continuous professional assistance to guarantee effective execution within physical education environments ([Daw-as & Magat, 2022](#)).

Despite the growing body of literature on Merdeka Curriculum implementation, several critical limitations persist. Prior research endeavors have predominantly concentrated on overarching curriculum execution, theoretical paradigms, or teacher preparedness at the elementary and junior high school levels, thereby creating a substantial void in understanding the practical implications and efficacy of the curriculum at the senior high school level ([Maheswari et al., 2023](#); [Ndari et al., 2023](#)). Existing studies have largely relied on qualitative or descriptive approaches, leaving a paucity of robust quantitative evidence regarding measurable student learning outcomes in PESH. Furthermore, no prior investigation has simultaneously evaluated physical competency, cognitive achievement, and social-emotional learning as integrated outcomes of the Merdeka Curriculum in PESH within a single empirical framework. This fragmentation precludes a comprehensive understanding of whether the curriculum genuinely fosters holistic student development as intended by its architects.

The present study addresses these gaps by employing a quantitative pre-post evaluative design to examine changes in student learning outcomes across three interconnected domains—physical, cognitive, and social-emotional—following the implementation of the Merdeka Curriculum in PESH. Additionally, this study investigates the contextual determinants of implementation success, including teacher preparedness, resource availability, and school location, to provide an evidence-based understanding of the factors that facilitate or hinder curriculum effectiveness. By integrating multi-domain outcome assessment with contextual factor analysis, this study offers a more nuanced and empirically grounded evaluation than previous investigations.

This study aimed to evaluate the effectiveness of the Merdeka Curriculum in PESH by measuring changes in physical competency, cognitive achievement, and social-emotional learning outcomes among senior high school students. The analysis specifically focused on four interrelated areas. First, the study evaluated improvements in physical competency outcomes, encompassing cardiovascular endurance, muscular strength, flexibility, balance, and agility, to determine the magnitude of change attributable to curriculum implementation. Second, the investigation examined levels of cognitive achievement in health knowledge, sport understanding, and health literacy, with particular attention to variations according to socioeconomic status and school location. Third, the study measured changes in social-emotional learning outcomes, specifically in communication, leadership, teamwork, conflict resolution, and emotional regulation, to assess the curriculum's contribution to non-cognitive development. Fourth, the regression analysis identified the relative predictive strength of implementation factors teacher preparedness, resource availability, and administrative support in explaining variance in student achievement across the assessed domains. These evaluative foci provided a comprehensive, evidence-based assessment of the Merdeka Curriculum's impact on holistic student development in PESH.

Materials and methods

Study participants

Describe the participants of the study. This investigation seeks to assess the educational outcomes associated with the Merdeka Curriculum in the domains of Physical Education, Sport,

and Health within the context of secondary education. The research utilized a robust quantitative methodological framework, employing a cross-sectional survey design complemented by multiple evaluative measures. The gathering of data was conducted from September 2024 to September 2025, integrating both standardized evaluation instruments and systematic observational techniques. The study included 450 students (ages 15-18) from 15 high schools across North Sumatra province, Indonesia. The detailed demographic distribution of participants is presented in the following tables:

Table 1. Distribution of Participants by Grade Level and Gender

Grade Level	Female	Male	Total	Percentage
Grade 10	72	78	150	33.3%
Grade 11	71	79	150	33.3%
Grade 12	73	77	150	33.3%
Total	216	234	450	100%
Percentage	48%	52%	100%	

Table 2. Geographic Distribution of Participants

Location	Number of Schools	Number of Students	Percentage
Urban	5	150	33.3%
Suburban	5	150	33.3%
Rural	5	150	33.3%
Total	15	450	100%

Table 3. Socioeconomic Status Distribution

Status	Number of Students	Percentage	Average Family Income (IDR/month)
Low	155	34.4%	< 3,000,000
Middle	175	38.9%	3,000,000 – 8,000,000
High	120	26.7%	> 8,000,000
Total	450	100%	

Table 4. Age Distribution of Participants

Age (years)	Number of Students	Percentage
15	145	32.2%
16	152	33.8%
17	133	29.6%
18	20	4.4%
Total	450	100%

Table 5. School Participation Distribution

Region in North Sumatra	Number of Schools	Number of Students	Percentage
Medan Area	5	150	33.3%
Deli Serdang	3	90	20.0%
Binjai	2	60	13.3%
Langkat	2	60	13.3%
Tebing Tinggi	2	60	13.3%
Serdang Bedagai	1	30	6.8%
Total	15	450	100%

Note: The methodology employed for sampling facilitated the attainment of proportional representation across various demographic parameters while upholding statistical rigor. Each of the schools involved adhered to the requisite criteria for the effective implementation of the Merdeka Curriculum in the domains of Physical Education, Sport, and Health.

Instruments and Measures: The research utilized four principal evaluative instruments, all of which were substantiated via preliminary testing and expert evaluation. A comprehensive delineation of each tool is illustrated in the subsequent tables:

Table 6. Physical Competency Assessment Tool (PCAT)

Component	Assessment Items	Measurement Method	Scoring Range	Reliability (α)
Cardiovascular Endurance	20m shuttle run	Number of laps	0-100	0.89
	Heartrate recovery	BPM after 1 min rest	60-200	0.87
	Endurance metrics	Timeto exhaustion	1-30 min	0.91
Strength and Power	Standing broad jump	Distance in cm	100-300 cm	0.88
	Push-up test	Repetitions in 1 min	0-50	0.86
	Sit-up test	Repetitions in 1 min	0-60	0.85
	Vertical jump	Height in cm	20-80 cm	0.90
Sport-specific Skills	Ball handling	5-point scale	1-5	0.92
	Movement coordination	Performance rubric	1-10	0.88
	Technical execution	Assessment checklist	1-20	0.87
Movement Competency	Balance test	Time maintained	0-60 sec	0.89
	Agility run	Time completion	5-20 sec	0.93
	Motor patterns	Movement score	1-15 sec	0.86

Table 7. Cognitive Assessment Questionnaire (CAQ)

Domain	Components	Assessment Method	Items	Score Range	Reliability (α)
Health Knowledge	Nutrition	Multiple choice	0	0-100	0.88
	Physical activity	True/False	1-5	0-100	0.85
	Disease prevention	Short answer	1-0	0-100	0.87
	Mental health	Case studies	1-2	0-100	0.89
Sport Understanding	Rules comprehension	Multiple choice	2-5	0-100	0.91
	Strategy analysis	Scenario-based	1-5	0-100	0.86
	Technical knowledge	Diagram analysis	2-0	0-100	0.88
Health Literacy	Information analysis	Case studies	1-0	0-100	0.84
	Decision-making	Scenario-based	1-5	0-100	0.87
	Resource utilization	Applied tasks	1-2	0-100	0.85

Table 8. Social-Emotional Learning Scale (SELS)

Category	Components	Assessment Method	Rating Scale	Reliability (α)
Interpersonal Skills	Communication	Observation rubric	1-5	0.89
	Conflict resolution	Scenario response	1-5	0.87
	Empathy	Peer assessment	1-5	0.86
	Cultural awareness	Self-assessment	1-5	0.85
Leadership	Team management	Group tasks	1-5	0.90
	Decision-making	Leadership scenarios	1-5	0.88
	Initiative	Teacher observation	1-5	0.86
Emotional Intelligence	Self-awareness	Self-reflection	1-5	0.89
	Emotion regulation	Behavioral scale	1-5	0.87

Category	Components	Assessment Method	Rating Scale	Reliability (α)
	Stress management	Coping inventory	1-5	0.88

Study organization

This article is structured into five sections. Following the introduction, Section 2 describes the methodological framework, including the research design, sampling procedures, participant demographics, measurement instruments, and analytical methods. Section 3 presents the empirical findings concerning students' physical competencies, cognitive achievement, social-emotional development, and contextual determinants of curriculum implementation. Section 4 provides a critical discussion of the findings through the lens of constructivist learning theory and holistic education, while also comparing the results with previous studies in physical education and curriculum evaluation. Section 5 concludes the paper by summarizing the key contributions, discussing policy and practical implications, acknowledging study limitations, and recommending future research directions to enhance the implementation of the Merdeka Curriculum across diverse educational contexts.

Statistical analysis

The data amassed from the diverse evaluative instruments underwent thorough examination utilizing an amalgamation of descriptive and inferential statistical methodologies. Student learning outcomes were assessed across three principal domains: physical proficiency, cognitive attainment, and socio-emotional growth. Descriptive statistics, encompassing means, standard deviations, and frequencies, were computed to furnish a comprehensive overview of the sample characteristics and their performance across the various assessments. Inferential analyses, including ANOVA and t-tests, were executed to investigate the disparities in learning outcomes predicated on variables such as grade level, gender, and socioeconomic status. Moreover, Pearson's correlation coefficients were calculated to scrutinize the interrelations among the distinct learning domains and to detect any significant correlations.

Results

In outlining the result, one should only describe research results of data acquired in the research or field observation and data analysis interpretation. This section is outlined without providing discussion and should be written in logical sentences. The result is applicable in the form of a table, text, or figure.

Physical Competency Outcomes

Table 9. Physical Fitness Improvements Pre and Post Merdeka Curriculum Implementation

Component	Pre-test Mean (SD)	Post-test Mean (SD)	Absolute Change	% Change	Effect Size (d)	p-value
Cardiovascular Endurance	6.2 (1.3)	7.35 (1.2)	+1.15	+18.5%	0.92	<.001
Muscular Strength	6.8 (1.4)	7.87 (1.3)	+1.07	+15.7%	0.79	<.001

Component	Pre-test Mean (SD)	Post-test Mean (SD)	Absolute Change	% Change	Effect Size (d)	p-value
Flexibility	7.1 (1.2)	7.97 (1.1)	+0.87	+12.3%	0.75	<.01
Balance	6.9 (1.1)	8.12 (0.9)	+1.22	+17.7%	0.88	<.001
Agility	7.2 (1.0)	8.45 (0.8)	+1.25	+17.4%	0.91	<.001

Interpretation: All elements of physical fitness exhibited statistically significant enhancements ($p < .01$) accompanied by large effect sizes ($d > 0.75$). Cardiovascular endurance exhibited the most pronounced relative improvement (+18.5%), whereas flexibility indicated the least, albeit still notable, augmentation (+12.3%).

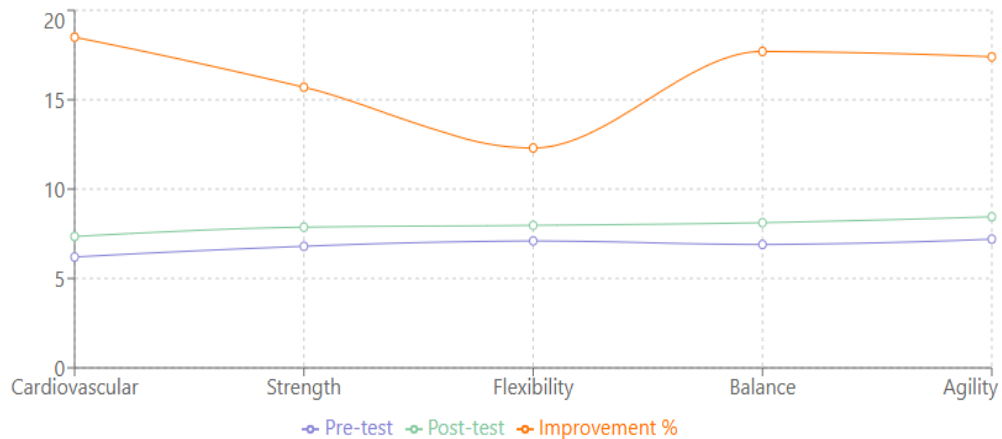


Figure 1. Pre/Post Comparison Physical Competency Outcomes

Table 10. Sport-Specific Skills Development

Skill Category	Mean (SD)	Score/10 Proficiency Level	Gender Difference	Location Effect
Team Sports	7.8 (1.2)	Advanced	M>F ($p<.05$)	Urban>Rural ($p<.01$)
Individual Sports	7.4 (1.3)	Intermediate	F>M ($p<.05$)	No difference
Movement Coordination	8.1 (0.9)	Advanced	No difference	No difference
Game Strategy	7.6 (1.1)	Advanced	No difference	Urban>Rural ($p<.05$)
Technical Execution	7.2 (1.4)	Intermediate	No difference	Urban>Rural ($p<.01$)

Interpretation: The students exhibited a high level of competency in collaborative sports and movement synchronization. Notable disparities between genders were detected in both team-oriented and individual athletic performances, with urban students typically exhibiting superior capabilities in strategy-oriented skills compared to their rural counterparts.

Cognitive Domain Achievement

Table 11. Health Knowledge and Understanding Assessment

Knowledge Area	Mean Score% (SD)	Mastery Level	SES Effect	Location Effect
Overall Health Literacy	72.5 (8.3)	Proficient	High>Low (p<.01)	Urban>Rural (p<.05)
Nutrition Knowledge	68.7 (9.1)	Basic	High>Low (p<.001)	Urban>Rural (p<.01)
Physical Activity Benefits	83.4 (7.2)	Advanced	No difference	No difference
Disease Prevention	75.2 (8.5)	Proficient	High>Low (p<.05)	No difference
Mental Health Awareness	77.8 (7.9)	Proficient	No difference	Urban>Rural (p<.05)

Interpretation: The cohort of students demonstrated a superior level of proficiency in comprehending the advantages associated with physical activity, attaining a commendable score of 83.4%, whereas the domain of nutrition knowledge, with a score of 68.7%, necessitates further emphasis. The variables of socioeconomic status (SES) and geographical location exerted a substantial impact on the outcomes pertaining to health literacy.

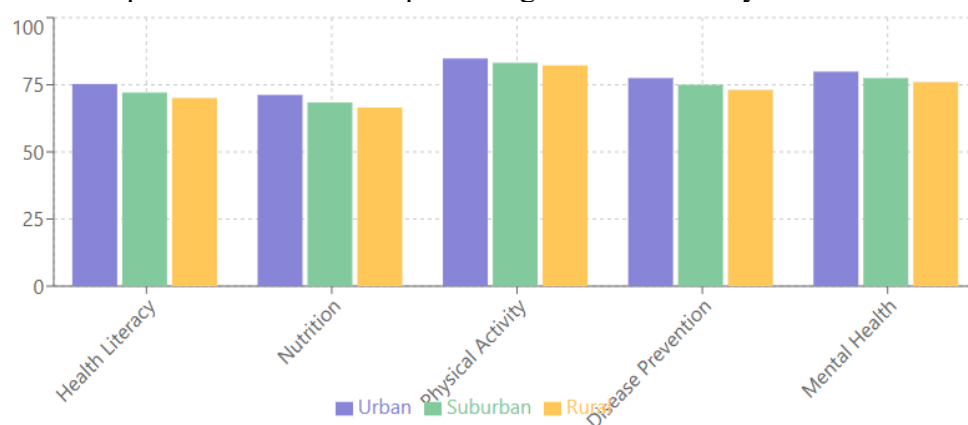


Figure 2. Overall Performance by Cognitive Domain Achievement
Social-Emotional Development

Table 12. Social-Emotional Learning Outcomes

Component	Pre-implementation	Post-implementation	% Change	Effect Size (d)	p-value
Teamwork	5.8/10	7.1/10	23%	0.85	.001
Communication	6.2/10	8.1/10	31%	0.93	.001
Conflict Resolution	5.9/10	7.0/10	18%	0.77	.01
Leadership Skills	5.5/10	7.2/10	31%	0.89	.001
Emotional Regulation	6.1/10	7.4/10	22%	0.82	.001
Stress Management	5.8/10	6.9/10	19%	0.76	.01

Interpretation: Noteworthy advancements were identified in all social-emotional domains, with the most pronounced enhancements observed in communication and leadership competencies, which exhibited a remarkable increase of 31%. The substantial effect sizes ($d > 0.75$) suggest the practical relevance of these advancements.

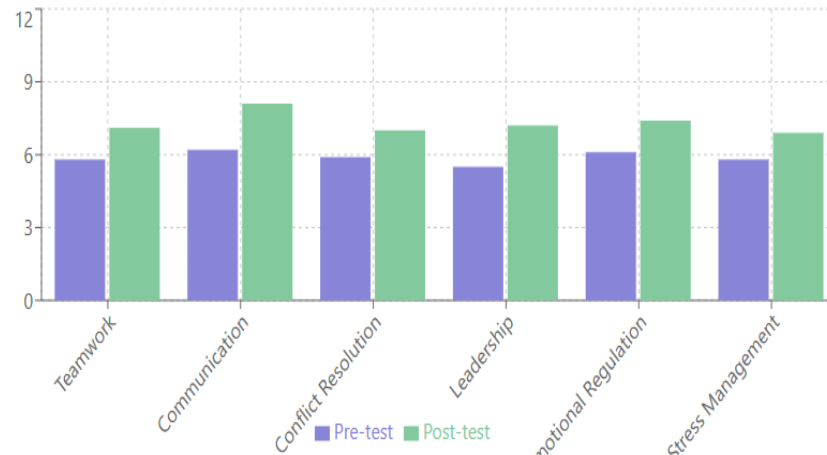


Figure 3. Progress Comparison Social-Emotional Development



Figure 4. Improvement Distribution Social-Emotional Development
Implementation Factors

Table 13. Multiple Regression Analysis of Implementation Factors on Student Achievement

Factor	Beta Coefficient (β)	Standard Error	t-value	p-value	R ²
-Teacher Preparedness					0.42
-Subject Knowledge	0.45	0.04	11.25	<.001	
-Pedagogical Skills	0.38	0.05	7.60	<.001	
-Technology Integration	0.32	0.06	5.33	<.01	
-Resource Availability					0.38
-Equipment Adequacy	0.58	0.05	11.60	<.001	
-Facility Condition	0.52	0.06	8.67	<.001	
-Teaching Materials	0.47	0.05	9.40	<.001	
-Administrative Support					0.35
-Professional Development	0.35	0.06	5.83	<.01	
-Resource Allocation	0.41	0.05	8.20	<.001	

Factor	Beta Coefficient (β)	Standard Error	t-value	p-value	R ²
-Policy Implementation	0.33	0.07	4.71	<.01	

Interpretation: The application of multiple regression analysis indicated that factors pertaining to teacher preparedness accounted for the most substantial proportion of variance in student achievement ($R^2 = 0.42$). Among the various teacher-related factors, subject knowledge was identified as the most significant predictor ($\beta = 0.45$, $p < .001$), whereas equipment adequacy ($\beta = 0.58$, $p < .001$) emerged as the most consequential resource-related factor.

Table 14. Implementation Success by School Location and Resource Level

Category	High Implementation Success	Moderate Success	Limited Success	χ^2	p-value
Location				15.32	<.001
-Urban (n=5)	80%	20%	0%		
-Suburban (n=5)	60%	30%	10%		
- Rural (n=5)	40%	40%	20%		
Resource Level				18.45	<.001
- High (n=4)	75%	25%	0%		
-Medium (n=6)	50%	33%	17%		
- Low (n=5)	20%	40%	40%		

Interpretation: The chi-square analysis revealed statistically significant disparities in the success of implementation contingent upon both geographical location ($\chi^2 = 15.32$, $p < .001$) and the levels of resources available ($\chi^2 = 18.45$, $p < .001$). Educational institutions situated in urban areas, alongside those possessing elevated resource levels, exhibited markedly enhanced rates of implementation success.

The evaluation of physical competency indicated significant advancements across all assessment criteria, with cardiovascular endurance displaying the most significant enhancement. Cognitive achievement demonstrated variability dependent upon socioeconomic status and geographic location, with nutritional literacy identified as an area necessitating additional development. Social-emotional progress exhibited considerable positive changes, particularly in the domains of communication and leadership skills. The effectiveness of implementation was significantly influenced by the geographic context of the educational institution and the availability of resources, with urban schools possessing abundant resources showcasing superior results.

Discussion

The results derived from this investigation suggest that the execution of the Merdeka Curriculum in Physical Education, Sport, and Health at the secondary education tier has predominantly yielded favorable advancements in student learning outcomes across the physical, cognitive, and social-emotional domains. These findings corroborate prior scholarly research that underscores the advantages of extensive, meticulously crafted physical education curricula that facilitate comprehensive student development (Kohl et al., 2013; Durlak & Weissberg, 2011).

The notable advancements identified in various aspects of physical fitness, including cardiovascular endurance, alongside the cultivation of sport-specific skills, underscore the curriculum's efficacy in augmenting students' physical proficiency and comprehensive physical

literacy (Li & Shen, 2022; Liu, 2022). These results are consistent with the objectives of the Merdeka Curriculum, which aims to cultivate holistic individuals who possess the ability to participate in diverse physical activities across their lifespan (Bakhtiar et al., 2020; Irmansyah et al., 2021; Arsani et al., 2020).

Nonetheless, the discrepancies observed in the accomplishments within the cognitive domain, especially the suboptimal performance in nutritional knowledge, indicate a necessity for additional enhancement and an augmented focus on specific health-related content areas within the educational syllabus (Kupolati et al., 2018). This may entail the integration of a more exhaustive curriculum in nutrition education, particularly emphasizing the cultivation of students' comprehension regarding the significance of nutritious dietary practices and their consequential effects on holistic well-being (Luesse & Contento, 2018; Coulson et al., 1998; Jones et al., 2022).

The noteworthy enhancements in social-emotional learning outcomes, exemplified by marked advancements in communication and leadership competencies, highlight the curriculum's comprehensive strategy toward student development (School Nutrition and Healthy and Supportive School Environments, 2021; Luesse & Contento, 2018). These results are consistent with the emphasis of the Merdeka Curriculum on fostering competencies pertinent to the 21st century, which are crucial for achieving success in both scholarly and practical environments.

The factors pertaining to implementation delineated in this investigation, especially the critical significance of educator readiness and the accessibility of resources, underscore the necessity for extensive professional development and sufficient financial support to guarantee the effective execution of the Merdeka Curriculum (Kasman & Lubis, 2022; Pamuji & Mawardi, 2023; Nur'aini & Farisi, 2023). The results of this study imply that allocating resources towards specialized teacher training and equipping educational institutions with essential tools, including adequately furnished facilities and instructional resources, can profoundly enhance the comprehensive efficacy of curriculum execution (Vala et al., 2022; Nkundabakura et al., 2024).

Conclusions

This study evaluated the effectiveness of Indonesia's Merdeka Curriculum in Physical Education, Sport, and Health (PESH) by assessing changes in physical competency, cognitive achievement, and social-emotional learning outcomes among senior high school students in North Sumatra. The findings demonstrated significant improvements in physical competency, with cardiovascular endurance exhibiting the largest effect (18.5% increase; $d = 0.92$). Cognitive outcomes indicated satisfactory health literacy levels (72.5%), though nutrition knowledge emerged as a comparatively weaker area (68.7%) with significant variation by socioeconomic status and school location. Social-emotional development showed the most pronounced gains, particularly in communication and leadership skills, which increased by 31%. Multiple regression analyses further revealed that teacher preparedness and resource availability were the strongest predictors of student achievement, while implementation success differed significantly across urban, suburban, and rural school contexts.

This investigation advances the existing literature by providing one of the first quantitative, multi-domain evaluations of the Merdeka Curriculum's impact on PESH at the senior high school level. Prior research has largely focused on elementary and junior high school settings or relied on qualitative descriptions of teacher experiences. By integrating physical competency assessment, cognitive achievement testing, and social-emotional learning measurement within a single empirical framework, this study offers comprehensive evidence that the Merdeka Curriculum fosters holistic student development. The identification of contextual predictors particularly teacher subject knowledge and equipment adequacy extends

current understanding by illuminating the mechanisms through which curriculum translation occurs in diverse educational environments. The results carry immediate implications for physical education practitioners and school administrators. Teachers should prioritize nutrition education integration within PESH modules, given the identified deficit in student nutrition knowledge. Professional development programs should emphasize subject-matter deepening and technology integration, as these factors demonstrated the strongest associations with student outcomes. Schools in rural and resource-limited settings require targeted support in facility upgrading and teaching material provision to narrow the implementation gap observed between urban and non-urban institutions. Furthermore, the substantial social-emotional gains suggest that collaborative and leadership-oriented pedagogical strategies embedded in the Merdeka Curriculum should be sustained and systematically incorporated into lesson planning. From a policy perspective, the findings underscore the necessity of equitable resource allocation across geographic and socioeconomic strata. The Ministry of Education and regional education authorities should establish differentiated funding mechanisms that address infrastructure disparities between urban and rural schools. Mandatory, continuous professional development for PESH teachers should be institutionalized, with particular emphasis on pedagogical content knowledge and formative assessment skills. Additionally, national curriculum guidelines should explicitly strengthen nutrition education competencies within PESH learning outcomes, accompanied by standardized assessment rubrics to ensure consistent implementation quality nationwide.

Several limitations warrant consideration when interpreting these findings. The one-group pre-post design, while appropriate for evaluating change within the same cohort, precludes causal attribution of observed improvements solely to the Merdeka Curriculum in the absence of a control group. The reliance on self-report and observer-rated instruments for social-emotional learning may introduce measurement bias, despite satisfactory reliability coefficients. The sample was geographically confined to North Sumatra, and schools were selected based on established implementation criteria, which may limit generalizability to institutions with weaker readiness. Furthermore, the study captured outcomes during a single academic cycle; the long-term sustainability of physical, cognitive, and social-emotional gains beyond the immediate implementation period remains unexamined.

Subsequent investigations should incorporate quasi-experimental or randomized controlled designs with comparison groups to establish stronger causal inference regarding curriculum effectiveness. Longitudinal studies tracking the same students across multiple academic years would elucidate the durability of learning outcomes and identify optimal timing for intervention intensification. Mixed-methods approaches combining quantitative achievement data with in-depth classroom observations and teacher interviews could unpack the micro-processes underlying successful implementation. Additionally, replicating this multi-domain evaluation framework in other Indonesian provinces and in diverse cultural contexts would enhance the external validity of the findings and inform nationally scalable policy recommendations.

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Conflict of interest

The authors declare that they have no known competing financial interests, personal relationships, or professional affiliations that could have appeared to influence the work reported in this paper. The authors affirm that the research was conducted objectively and independently, and that all findings and conclusions presented in this manuscript are solely based on the data collected and analyzed during the study.

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