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Developing a Structural Model of the Effect of a Cognitive Science- and Physical Activity-Based Curriculum on Self-Regulated Learning, Cognitive Flexibility, and Mental Health in Students

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A B S T R A C T

The present study aimed to develop and test a structural model explaining the effect of a cognitive science- and physical activity-based curriculum on self-regulated learning, cognitive flexibility, and mental health among secondary school students in Tehran. This quantitative study was conducted using a descriptive-correlational design based on structural equation modeling. The statistical population included secondary school students in Tehran during the academic year 2025–2026, from whom 384 students were selected through multistage cluster sampling. Data were collected using a demographic information form, a researcher-made questionnaire for assessing the cognitive science- and physical activity-based curriculum, the Self-Regulated Learning Questionnaire, the Cognitive Flexibility Inventory, and the General Health Questionnaire. The validity of the measurement model was examined through confirmatory factor analysis, and reliability was assessed using Cronbach's alpha and composite reliability. Data were analyzed using SPSS and AMOS software. Descriptive indices, normality indices, correlation coefficients, confirmatory factor analysis, model fit indices, standardized path coefficients, and indirect effects were examined. The structural model showed acceptable fit with the data, with $\chi^2/df = 1.92$, CFI = 0.951, TLI = 0.943, GFI = 0.918, AGFI = 0.900, RMSEA = 0.049, and SRMR = 0.044. The cognitive science- and physical activity-based curriculum had significant direct effects on self-regulated learning ($\beta = 0.62$, $p < 0.001$), cognitive flexibility ($\beta = 0.54$, $p < 0.001$), and mental health ($\beta = 0.31$, $p < 0.001$). Self-regulated learning significantly predicted mental health ($\beta = 0.24$, $p < 0.001$), and cognitive flexibility also had a significant effect on mental health ($\beta = 0.29$, $p < 0.001$). The curriculum also had significant indirect effects on mental health through self-regulated learning and cognitive flexibility. The model explained 38% of the variance in self-regulated learning, 29% of the variance in cognitive flexibility, and 49% of the variance in mental health. The findings indicated that a curriculum based on cognitive science and physical activity can improve students' self-regulated learning, strengthen cognitive flexibility, and promote mental health.

Keywords: *Cognitive science-based curriculum; physical activity; self-regulated learning; cognitive flexibility; mental health; structural equation modeling; students.*

1. Introduction

In contemporary educational systems, the curriculum is no longer understood merely as a formal sequence of instructional content, but as a dynamic developmental environment that shapes students' cognitive functioning, learning behaviors, emotional adjustment, and psychological well-being. This expanded understanding has become especially important in adolescence, a period marked by rapid neurocognitive development, increasing academic demands, heightened sensitivity to social evaluation, and greater vulnerability to stress, anxiety, motivational decline, and maladaptive learning patterns. Students today are expected not only to acquire knowledge, but also to regulate their attention, monitor their learning, adapt to complex problems, cope with academic pressure, and maintain mental health in increasingly demanding school contexts. Therefore, the design of curricula that simultaneously address cognitive, behavioral, and psychological dimensions of student development has become a central concern in educational research. Recent literature on child and adolescent well-being emphasizes that mental health should be treated as an integral component of educational planning rather than a peripheral concern, because psychological functioning directly influences learning engagement, academic adaptation, peer interaction, and long-term developmental outcomes (P. et al., 2024; Subramanyam et al., 2024).

One promising direction in curriculum development is the integration of cognitive science principles into educational design. Cognitive science provides a theoretical and empirical foundation for understanding how students attend to information, encode and retrieve knowledge, regulate cognitive load, use executive functions, make decisions, solve problems, and adapt their thinking to changing demands. From this perspective, an effective curriculum is not limited to the transmission of subject matter; rather, it should be designed to activate attention, working memory, inhibitory control, cognitive flexibility, metacognition, and self-monitoring. Neuroscience-informed approaches to adolescence also suggest that strengthening cognitive resilience and adaptive self-regulatory capacities during this developmental period may have protective effects against academic and psychological vulnerability (Rezapour et al., 2020). Accordingly, a curriculum grounded in cognitive science can create learning conditions that help students become active processors of information, reflective learners, and flexible problem-solvers.

Self-regulated learning is one of the most important outcomes of cognitively informed curriculum design. Self-regulated learning refers to the capacity of learners to set goals, plan learning activities, monitor comprehension, select strategies, regulate motivation, manage effort, and evaluate outcomes. In school settings, students with stronger self-regulated learning skills are more capable of sustaining attention, organizing academic tasks, overcoming obstacles, and maintaining purposeful engagement with learning. These capacities are not spontaneous traits; they are shaped by instructional environments that provide meaningful tasks, feedback, opportunities for reflection, and metacognitive scaffolding. Educational programs that include mindfulness, emotional awareness, and reflective practices have shown potential for strengthening students' attention, awareness, academic functioning, and mental adaptation (Indriaswuri et al., 2023; Shapiro et al., 2024). Therefore, a cognitive science-based curriculum may support self-regulated learning by explicitly connecting cognitive engagement, metacognitive monitoring, emotional regulation, and strategy use within daily classroom activities.

Cognitive flexibility is another central construct in the proposed model. Cognitive flexibility refers to the ability to shift perspectives, generate alternative solutions, adapt to new information, and modify strategies when previous approaches are ineffective. This capacity is essential for academic learning because students frequently encounter novel problems, conflicting information, changing task demands, and emotionally challenging learning situations. Cognitive flexibility also has psychological significance because students who can reinterpret difficulties, consider alternative responses, and perceive challenges as manageable may be less vulnerable to rigid thinking, avoidance, anxiety, and academic helplessness. School-based interventions that target cognitive, emotional, and wellness-related processes increasingly emphasize

adaptability, psychological flexibility, and resilience as essential components of student development (Hikmat et al., 2025; Razza et al., 2025; Sapulette et al., 2025). Thus, curriculum models that stimulate flexible thinking and adaptive problem-solving can play an important role in both educational achievement and mental health promotion.

Alongside cognitive science, physical activity has emerged as a major educational and developmental resource. A growing body of research indicates that movement, exercise, active breaks, physical education, and sport-based experiences are associated with improved psychological health, cognitive functioning, classroom engagement, and well-being among students. Physical activity may influence students through multiple pathways, including increased arousal regulation, improved mood, reduced stress, enhanced executive function, better social interaction, and greater enjoyment of school activities. Studies on school and university populations have shown that physical activity interventions, active breaks, yoga-based programs, and sport-related activities can contribute to mental health, academic functioning, and cognitive outcomes (Latino, Tafuri, & Tafuri, 2025; Latino, Tafuri, Maisuradze, et al., 2025; Martín-Rodríguez et al., 2024; Ruíz et al., 2025). These findings support the view that physical activity should not be treated as separate from academic learning, but as a meaningful component of curriculum design.

The educational value of physical activity is especially relevant in response to sedentary lifestyles among young people. Contemporary students often spend long periods in seated classroom instruction, screen-based learning, and fragmented daily routines that reduce opportunities for purposeful movement. This pattern can negatively affect physical health, attention, motivation, emotional balance, and social development. Research on youth sedentary behavior has emphasized the need for practical strategies that incorporate movement into daily routines and school structures, even through small periods of fragmented time (Aslam & Bin, 2025). In addition, studies on elementary and school-aged students indicate that physical activity can improve psychological well-being, enjoyment, and mental health when integrated into educational contexts in developmentally appropriate ways (B., 2024; Bagum et al., 2024; Papadopoulos et al., 2022). Therefore, a curriculum based on both cognitive science and physical activity can provide a multidimensional response to the cognitive inactivity and behavioral passivity often observed in traditional classroom models.

The integration of physical education into the curriculum is not without challenges, but its potential benefits are substantial. Physical education and movement-based learning contribute to the development of motor skills, cooperation, discipline, emotional expression, social responsibility, and community participation. Previous work has described physical education and sport as foundational elements for community health and human development, while also emphasizing the importance of school facilities and accessible environments in supporting students' physical engagement (Habyarimana et al., 2022; Mun, 2021). At the same time, curriculum integration requires attention to instructional planning, teacher competence, time allocation, cultural expectations, and institutional support (Sharma & Upreti, 2023). These considerations indicate that a physical activity-based curriculum should not be limited to isolated exercise sessions; rather, it should be structurally embedded in learning activities and aligned with cognitive and psychological objectives.

Mental health is a key outcome in the present model because students' psychological well-being is strongly connected to their learning processes. Stress, anxiety, mood disturbance, academic pressure, and poor emotional regulation can reduce attention, impair memory, weaken motivation, and interfere with classroom participation. Studies on stress management, emotional intelligence, resilience, and psychoeducational interventions have shown that structured educational programs can reduce subclinical stress and anxiety and strengthen students' adaptive capacities (Ang et al., 2022; Papageorgiou et al., 2025; Sevindik & Mansuroğlu, 2025). Similarly, research on students entering university highlights the relationship between stress management, mood, academic adaptation, and performance, suggesting that psychological adjustment is closely linked with educational functioning (Cóndor et al., 2024). Although the present study focuses on school students rather than university students, these findings reinforce the broader theoretical assumption that educational environments must be designed to support emotional and psychological regulation.

Mindfulness-based, nature-based, and wellness-oriented approaches also provide relevant support for the development of integrated curricula. School mindfulness interventions have been associated with anxiety reduction, depression prevention, positive school climate, and student well-being, while teacher and student perceptions of mindfulness-based mental health curricula indicate that such programs can be meaningful when adapted to educational

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realities (Folger et al., 2023; Monsillion et al., 2023). Nature-based and ecodaemonia-oriented approaches further emphasize the role of environmental connectedness, meaning, and holistic development in school counseling and student support programs (Greenleaf & Reese, 2024; Vitagliano et al., 2023). These perspectives are important because they show that student mental health can be supported through curriculum-level design rather than only through remedial or clinical services. In this sense, a cognitive science- and physical activity-based curriculum may operate as a universal developmental framework that promotes adaptive learning, flexible thinking, and well-being for all students.

The growing use of digital and remote interventions also demonstrates the need to rethink how cognitive and psychological support can be delivered within and beyond traditional classrooms. During and after the COVID-19 pandemic, educational and psychological services increasingly relied on telehealth, online programs, mobile mental well-being interventions, and multimodal activity breaks to support learners' mental health and engagement (Baker et al., 2024; Marschin & Herbert, 2021; McCallum et al., 2022). Although digital interventions can improve accessibility, they also reveal the limitations of purely screen-based learning environments when students lack embodied engagement, social interaction, and structured self-regulation. This reinforces the relevance of curriculum models that combine cognitive activation with physical movement, emotional support, and active classroom participation.

The concept of wellness has also become increasingly important in education and professional preparation. Holistic wellness approaches emphasize sustainable practices, emotional balance, self-care, resilience, and supportive institutional cultures (Argus-Calvo et al., 2024). In higher education, mindfulness and well-being programs have been used to enhance students' psychological adjustment and community well-being (Barker et al., 2021). Although these studies are often conducted in university or professional settings, their implications are applicable to school curriculum development because the foundations of lifelong wellness, self-regulation, and adaptive coping are formed earlier in educational trajectories. A curriculum that combines cognitive science and physical activity can therefore be viewed as an early educational investment in students' lifelong learning capacities and psychological health.

Despite the expansion of research on physical activity, mindfulness, resilience, mental health, and cognitive interventions, several gaps remain. First, many studies examine physical activity, mental health, cognitive performance, or self-regulation as separate domains, while fewer studies propose integrated structural models that connect curriculum design to multiple cognitive and psychological outcomes. Second, existing interventions often focus on isolated programs, such as mindfulness training, yoga, active breaks, counseling interventions, or digital mental health programs, rather than examining how curriculum-level design can systematically influence students' learning regulation, cognitive flexibility, and mental health. Third, the mechanisms through which curriculum experiences affect mental health remain insufficiently explained. Theoretical and empirical evidence suggests that self-regulated learning and cognitive flexibility may function as important mediating or explanatory pathways, but these relationships require structural testing within student populations. Finally, in educational contexts such as Tehran, there is a need for empirical models that connect contemporary cognitive science, movement-based learning, and student well-being in a culturally and institutionally relevant framework.

Based on these considerations, the present study was conducted to develop and test a structural model of the effect of a cognitive science- and physical activity-based curriculum on self-regulated learning, cognitive flexibility, and mental health among students in Tehran.

2. Methods and Materials

2.1. Study Design and Participants

The present study was conducted using a quantitative, descriptive-correlational design based on structural equation modeling. The purpose of this design was to develop and test a structural model explaining the effect of a curriculum based on cognitive science and physical activity on students' self-regulated learning, cognitive flexibility, and mental health. The statistical population consisted of secondary school students in Tehran during the academic year 2025–2026. Using multistage cluster sampling, several educational districts of Tehran were first selected, then schools were randomly chosen from each selected district, and finally eligible students were selected from different classes. The final sample included 384 students from Tehran. This sample size was considered adequate for structural equation modeling because it provided sufficient statistical power for

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estimating direct and indirect paths among the latent variables of the model. Inclusion criteria were enrollment in secondary school, willingness to participate in the study, ability to complete the questionnaires independently, and absence of incomplete responses in the research instruments. Students who returned incomplete questionnaires or did not provide informed consent were excluded from the final analysis. Before data collection, the objectives of the study were explained to the students, and they were assured that participation was voluntary, that their information would remain confidential, and that the collected data would be used only for research purposes.

2.2. Measures

Data were collected using a demographic information form and four main questionnaires. The demographic form included questions about age, gender, grade level, type of school, and educational background. To measure the cognitive science- and physical activity-based curriculum, a researcher-made questionnaire was developed according to the theoretical foundations of cognitive science, embodied cognition, executive functions, active learning, movement-based learning, and curriculum design. This questionnaire included items related to cognitive engagement, attention and executive control, metacognitive guidance, integration of physical activity into learning tasks, feedback-based learning, emotional-motivational support, and active classroom participation. The items were scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree," with higher scores indicating greater perceived implementation of a curriculum based on cognitive science and physical activity. The face and content validity of the questionnaire were examined by specialists in curriculum studies, educational psychology, cognitive science, and physical education. The reliability of the questionnaire was assessed using Cronbach's alpha and composite reliability, both of which indicated acceptable internal consistency.

Self-regulated learning was measured using the Self-Regulated Learning Questionnaire based on the theoretical framework of Pintrich and colleagues. This instrument evaluates students' ability to plan, monitor, regulate, and evaluate their learning processes. The questionnaire assesses cognitive strategies, metacognitive strategies, motivational regulation, effort regulation, and management of learning resources. Items are scored on a Likert scale, and higher scores indicate stronger self-regulated learning skills. This instrument has been widely used in educational and psychological research, and previous studies have confirmed its validity and reliability among student populations. In the present study, the internal consistency of the scale was also examined using Cronbach's alpha, and the obtained coefficient confirmed that the instrument had acceptable reliability for the study sample.

Cognitive flexibility was assessed using the Cognitive Flexibility Inventory developed by Dennis and Vander Wal. This questionnaire measures the individual's perceived ability to adapt cognitive strategies in response to changing environmental demands, generate alternative solutions, and perceive difficult situations as controllable. The instrument includes two main dimensions: alternatives and control. The items are scored on a Likert scale, with higher scores indicating greater cognitive flexibility. The Cognitive Flexibility Inventory has been used in numerous studies in educational and psychological contexts, and its psychometric properties have been confirmed in different populations. In the present study, confirmatory factor analysis and internal consistency indices were used to evaluate the adequacy of the measurement model and reliability of the scale.

Mental health was measured using the General Health Questionnaire developed by Goldberg and Hillier. This instrument is one of the most commonly used tools for assessing general mental health status and psychological distress. The questionnaire evaluates dimensions such as somatic symptoms, anxiety and sleep disturbance, social dysfunction, and depressive symptoms. Items are scored according to the standard scoring procedure of the instrument, and the total score reflects the respondent's general mental health condition. Depending on the scoring direction used in the analysis, higher scores were interpreted according to the scale manual. The General Health Questionnaire has shown acceptable validity and reliability in previous studies, including studies conducted with student populations. In the present study, the reliability of the questionnaire was assessed using Cronbach's alpha, and the measurement model was evaluated before testing the structural model.

2.3. Data Analysis

Data analysis was performed using SPSS and AMOS software. First, the collected questionnaires were reviewed, incomplete responses were removed, and the final dataset was prepared for analysis. Descriptive statistics, including

mean, standard deviation, minimum, maximum, skewness, and kurtosis, were calculated for all main variables. The normality of the data was examined using skewness and kurtosis indices, and the assumptions required for structural equation modeling were evaluated before testing the model. Reliability was assessed using Cronbach's alpha and composite reliability, and convergent validity was examined using average variance extracted. Confirmatory factor analysis was then conducted to evaluate the measurement models of the latent variables, including the cognitive science- and physical activity-based curriculum, self-regulated learning, cognitive flexibility, and mental health.

After confirming the adequacy of the measurement models, the structural model was tested to examine the direct effects of the cognitive science- and physical activity-based curriculum on self-regulated learning, cognitive flexibility, and mental health. Model fit was evaluated using standard fit indices, including chi-square divided by degrees of freedom, comparative fit index, Tucker–Lewis index, goodness-of-fit index, adjusted goodness-of-fit index, root mean square error of approximation, and standardized root mean square residual. Acceptable model fit was determined based on conventional thresholds for structural equation modeling. The significance of path coefficients was examined using standardized regression weights, critical ratios, and significance levels. The final model was interpreted according to the magnitude and direction of the standardized path coefficients, and the results were used to explain the structural relationships among curriculum, self-regulated learning, cognitive flexibility, and mental health in students.

3. Findings and Results

Before testing the structural model, the demographic characteristics of the participants were examined. The final sample consisted of 384 secondary school students from Tehran. Of these students, 198 were female and 186 were male, representing 51.6% and 48.4% of the sample, respectively. The age of the participants ranged from 13 to 18 years, with a mean age of 15.42 years and a standard deviation of 1.39. In terms of grade level, 55 students were in the seventh grade, 63 were in the eighth grade, 68 were in the ninth grade, 66 were in the tenth grade, 64 were in the eleventh grade, and 68 were in the twelfth grade. Regarding school type, 251 students were studying in public schools and 133 students were studying in private schools. Overall, the demographic distribution indicated that the sample included students from different educational levels and school contexts in Tehran, which provided an appropriate basis for examining the proposed structural relationships among the main research variables.

Table 1

Descriptive statistics, normality indices, and correlations among the main research variables

Variable	Mean	SD	Skewness	Kurtosis	1	2	3	4
Cognitive science- and physical activity-based curriculum	3.52	0.62	-0.31	0.44	1			
Self-regulated learning	3.47	0.59	-0.28	0.39	0.58**	1		
Cognitive flexibility	3.41	0.64	-0.22	0.36	0.51**	0.57**	1	
Mental health	3.36	0.66	-0.19	0.41	0.44**	0.48**	0.52**	1

As shown in Table 1, the mean scores of all main variables were above the theoretical midpoint of the scale, indicating that students reported a relatively favorable level of exposure to a cognitive science- and physical activity-based curriculum, self-regulated learning, cognitive flexibility, and mental health. The highest mean score belonged to the cognitive science- and physical activity-based curriculum, while the lowest mean score was related to mental health. The skewness and kurtosis values of all variables were within the acceptable range of -2 to +2, indicating that the distribution of the variables did not substantially violate the assumption of univariate normality. The correlation coefficients also showed that the cognitive science- and physical activity-based curriculum had a positive and significant relationship with self-regulated learning, cognitive flexibility, and mental health. The strongest correlation of the curriculum variable was observed with self-regulated learning, suggesting that students who experienced a more cognitively enriched and physically active curriculum tended to report stronger planning, monitoring, regulation, and control of their learning processes. Self-regulated learning and cognitive flexibility were also positively and significantly associated with mental health, indicating that students with stronger regulatory and adaptive cognitive capacities tended to report better psychological functioning.

Table 2

Measurement model results, reliability, and convergent validity of latent variables

Latent variable	Number of indicators	Standardized factor loading range	Cronbach's alpha	Composite reliability	Average variance extracted
Cognitive science- and physical activity-based curriculum	7	0.64–0.83	0.91	0.92	0.62
Self-regulated learning	5	0.68–0.84	0.89	0.90	0.64
Cognitive flexibility	2	0.73–0.87	0.86	0.87	0.68
Mental health	4	0.65–0.82	0.88	0.89	0.60

The results of the confirmatory factor analysis presented in Table 2 indicated that the measurement model had acceptable psychometric quality. The standardized factor loadings of all indicators were higher than 0.60, showing that each observed indicator had an adequate contribution to its corresponding latent construct. The cognitive science- and physical activity-based curriculum showed strong factor loadings across its components, including cognitive engagement, executive control, metacognitive guidance, physical activity integration, feedback-based learning, emotional-motivational support, and active participation. The self-regulated learning construct also showed adequate measurement quality through its cognitive, metacognitive, motivational, effort regulation, and resource management dimensions. The two dimensions of cognitive flexibility, namely alternatives and control, demonstrated strong loadings, confirming that the construct was measured coherently. The four dimensions of mental health also loaded acceptably on the latent construct. Cronbach's alpha values ranged from 0.86 to 0.91, and composite reliability values ranged from 0.87 to 0.92, indicating satisfactory internal consistency and reliability. In addition, the average variance extracted values were all above 0.50, confirming the convergent validity of the constructs used in the structural model.

Table 3

Fit indices of the measurement model and structural model

Model	χ^2	df	χ^2/df	CFI	TLI	GFI	AGFI	RMSEA	SRMR
Measurement model	412.38	221	1.87	0.956	0.947	0.923	0.901	0.048	0.041
Structural model	438.72	228	1.92	0.951	0.943	0.918	0.900	0.049	0.044

According to Table 3, both the measurement model and the final structural model demonstrated acceptable fit with the observed data. The chi-square divided by degrees of freedom was lower than 3 in both models, indicating that the discrepancy between the proposed model and the empirical data was within an acceptable range. The comparative fit index and Tucker–Lewis index were both above 0.90 and close to 0.95, which confirmed the adequacy of the comparative fit of the models. The goodness-of-fit index and adjusted goodness-of-fit index also supported the overall appropriateness of the model structure. Furthermore, the root mean square error of approximation was below 0.05 in both models, and the standardized root mean square residual was below 0.08, indicating a low level of residual error. These findings showed that the proposed theoretical model was empirically supported and could be used to explain the relationships among the cognitive science- and physical activity-based curriculum, self-regulated learning, cognitive flexibility, and mental health among students.

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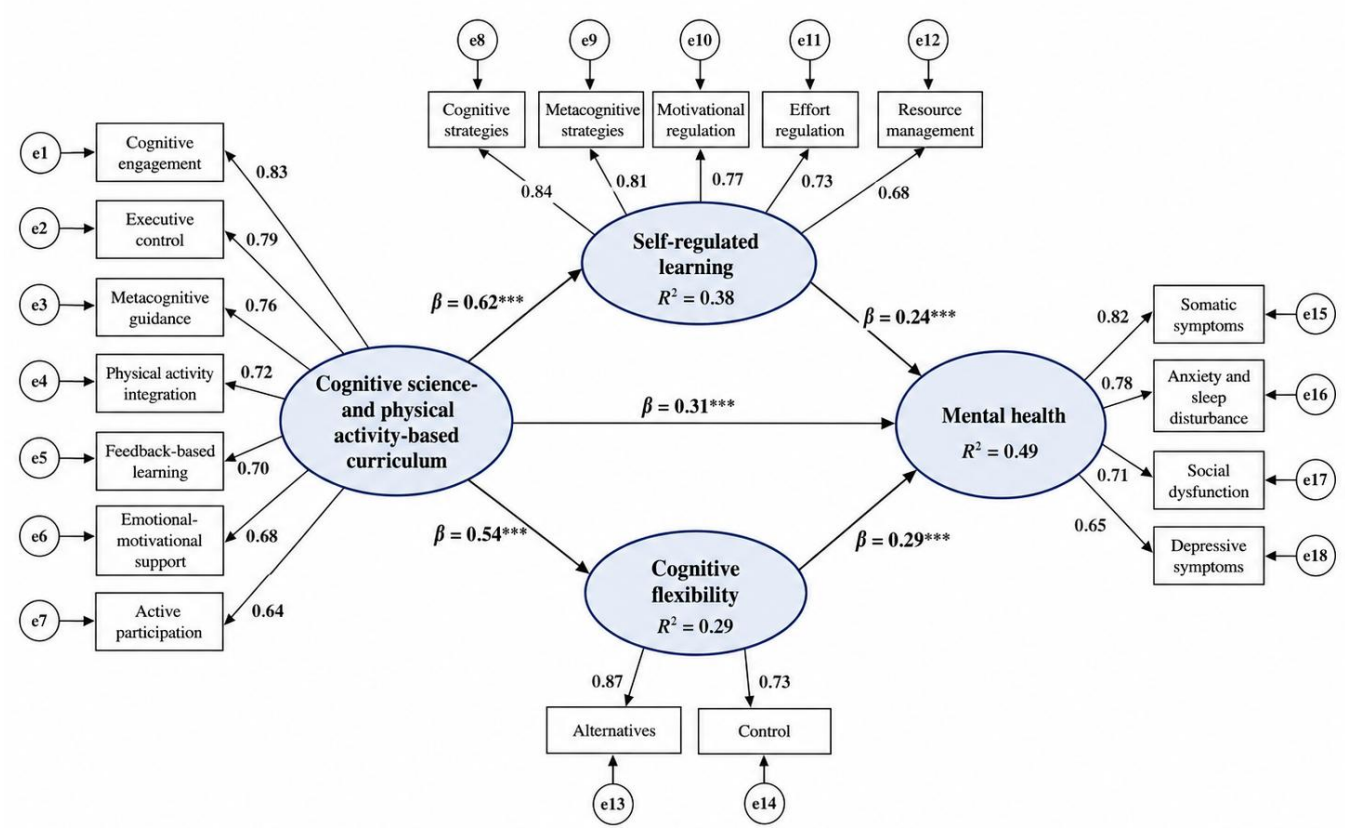
Figure 1

Final structural model of the effect of the cognitive science- and physical activity-based curriculum on self-regulated learning, cognitive flexibility, and mental health



The final structural model showed that the cognitive science- and physical activity-based curriculum was positioned as the exogenous latent variable, while self-regulated learning, cognitive flexibility, and mental health were positioned as endogenous latent variables. In this model, the curriculum directly predicted self-regulated learning, cognitive flexibility, and mental health. In addition, self-regulated learning and cognitive flexibility were included as psychological and cognitive mechanisms that contributed to students' mental health. The structure of the model indicated that curriculum experiences based on cognitive science and physical activity were not limited to academic learning processes but were also meaningfully associated with students' adaptive cognitive functioning and psychological well-being. The model therefore supported the assumption that an educational program integrating cognitive engagement, executive function stimulation, metacognitive regulation, active bodily movement, and feedback-based learning can contribute to students' capacity for self-regulation, flexible thinking, and mental health.

Table 4

Direct path coefficients in the final structural model

Structural path	Unstandardized coefficient	SE	Standardized coefficient	Critical ratio	p-value	Result
Curriculum → Self-regulated learning	0.57	0.06	0.62	9.82	<0.001	Supported
Curriculum → Cognitive flexibility	0.49	0.06	0.54	8.18	<0.001	Supported
Curriculum → Mental health	0.28	0.07	0.31	4.33	<0.001	Supported
Self-regulated learning → Mental health	0.22	0.06	0.24	3.78	<0.001	Supported
Cognitive flexibility → Mental health	0.31	0.07	0.29	4.61	<0.001	Supported

As presented in Table 4, all direct paths in the final structural model were positive and statistically significant. The cognitive science- and physical activity-based curriculum had the strongest direct effect on self-regulated

learning, indicating that students who perceived their curriculum as more cognitively stimulating, physically active, and metacognitively supportive were more likely to demonstrate stronger self-regulatory learning behaviors. The curriculum also had a significant positive effect on cognitive flexibility, showing that learning environments that combine cognitive science principles with movement-based activities can strengthen students' ability to adapt to new situations, generate alternative solutions, and control their thinking when facing academic or emotional challenges. The direct path from the curriculum to mental health was also significant, suggesting that such a curriculum may contribute to students' psychological well-being through increased engagement, active participation, emotional support, and reduction of passive or monotonous learning experiences. Furthermore, self-regulated learning and cognitive flexibility both had significant positive effects on mental health. These results indicate that students who are better able to organize and monitor their learning and who can respond flexibly to changing academic demands are more likely to experience better mental health status.

Table 5

Explained variance and indirect effects in the structural model

Endogenous variable or effect	R^2 or effect value	SE	95% confidence interval	p-value
Explained variance of self-regulated learning	0.38	—	—	—
Explained variance of cognitive flexibility	0.29	—	—	—
Explained variance of mental health	0.49	—	—	—
Curriculum → Self-regulated learning → Mental health	0.15	0.04	0.08–0.24	<0.001
Curriculum → Cognitive flexibility → Mental health	0.16	0.04	0.09–0.26	<0.001
Total indirect effect of curriculum on mental health	0.31	0.06	0.20–0.43	<0.001
Total effect of curriculum on mental health	0.62	0.07	0.49–0.75	<0.001

The results presented in Table 5 showed that the final structural model explained 38% of the variance in self-regulated learning, 29% of the variance in cognitive flexibility, and 49% of the variance in mental health. These values indicate that the proposed model had a substantial explanatory capacity, especially for mental health. The indirect effect of the cognitive science- and physical activity-based curriculum on mental health through self-regulated learning was positive and significant, suggesting that one way through which the curriculum improved mental health was by strengthening students' ability to plan, monitor, and regulate their own learning. The indirect effect of the curriculum on mental health through cognitive flexibility was also significant, indicating that the curriculum contributed to mental health by promoting adaptive thinking, cognitive control, and the ability to consider alternative responses to academic and personal challenges. The total indirect effect of the curriculum on mental health was significant, and the total effect was stronger than the direct effect alone. This finding demonstrates that the relationship between the curriculum and mental health was both direct and mechanism-based. In other words, the curriculum affected students' mental health not only through its immediate educational and emotional features but also through the enhancement of self-regulated learning and cognitive flexibility as important cognitive and psychological mediators.

Overall, the findings confirmed the proposed structural model. The cognitive science- and physical activity-based curriculum had significant positive effects on self-regulated learning, cognitive flexibility, and mental health. In addition, self-regulated learning and cognitive flexibility significantly predicted mental health and played explanatory roles in the relationship between curriculum and psychological well-being. These results suggest that a curriculum designed on the basis of cognitive science and physical activity can support students' academic self-management, strengthen their adaptive cognitive capacity, and improve their mental health status. Therefore, the final model provides empirical support for the integration of cognitive science principles and structured physical activity into school curricula as a multidimensional educational approach for improving both learning-related and psychological outcomes among students.

4. Discussion

The present study was conducted to develop and test a structural model of the effect of a cognitive science- and physical activity-based curriculum on self-regulated learning, cognitive flexibility, and mental health among

students in Tehran. The findings confirmed the overall adequacy of the proposed model and showed that the cognitive science- and physical activity-based curriculum had significant positive effects on self-regulated learning, cognitive flexibility, and mental health. In addition, self-regulated learning and cognitive flexibility significantly predicted students' mental health and functioned as important explanatory mechanisms in the model. These results indicate that when curriculum design incorporates cognitive engagement, executive control, metacognitive guidance, active participation, feedback-based learning, and structured physical activity, students are more likely to develop adaptive learning behaviors, flexible thinking patterns, and healthier psychological functioning. The model explained 38% of the variance in self-regulated learning, 29% of the variance in cognitive flexibility, and 49% of the variance in mental health, suggesting that the proposed curriculum framework has considerable explanatory power in relation to both educational and psychological outcomes.

The first major finding showed that the cognitive science- and physical activity-based curriculum had a strong and significant direct effect on self-regulated learning. This result suggests that students who experience a curriculum designed around cognitive activation, metacognitive awareness, movement-based learning, and feedback are more capable of planning, monitoring, regulating, and evaluating their own learning. This finding is consistent with the theoretical assumption that self-regulated learning is not merely an individual trait but is shaped by the instructional environment. A curriculum that stimulates attention, encourages active participation, requires students to reflect on their learning strategies, and integrates bodily activity into classroom tasks can strengthen learners' sense of control over their academic behavior. This result aligns with studies emphasizing the educational value of mindfulness, cognitive awareness, and reflective learning in improving students' attention, academic performance, and psychological adaptation (Indriaswuri et al., 2023; Shapiro et al., 2024). It is also consistent with research showing that resilience-oriented and psychoeducational interventions can improve students' self-management and adaptive functioning in educational settings (Ang et al., 2022; Papageorgiou et al., 2025).

The significant effect of the curriculum on self-regulated learning can also be explained through the role of physical activity in activating attention, motivation, and behavioral engagement. Physical activity integrated into learning may reduce passive classroom behavior and create opportunities for students to experience learning as an embodied and participatory process. In this regard, studies on active breaks and movement-based interventions have shown that even brief physical activity embedded in educational contexts can enhance cognitive functioning, academic outcomes, and mental well-being (Latino, Tafuri, & Tafuri, 2025; Latino, Tafuri, Maisuradze, et al., 2025). Similarly, research on classroom-based physical activity interventions indicates that such programs can increase enjoyment, subjective well-being, and engagement among school-aged children (Papadopoulos et al., 2022). Therefore, the present finding supports the view that integrating cognitive science principles with physical activity can provide a more effective curriculum structure for developing self-regulated learners.

The second major finding indicated that the cognitive science- and physical activity-based curriculum had a significant positive effect on cognitive flexibility. This result means that students exposed to a cognitively enriched and physically active curriculum demonstrated greater capacity to generate alternative solutions, adapt to changing learning situations, and perceive challenges as controllable. Cognitive flexibility is closely related to executive functioning and adaptive problem-solving; therefore, a curriculum that emphasizes active engagement, executive control, feedback, and metacognitive reflection can strengthen students' ability to shift strategies and respond flexibly to academic demands. This finding is consistent with neuroscience-informed perspectives that emphasize the importance of strengthening cognitive resilience during adolescence and young adulthood (Rezapour et al., 2020). It is also aligned with studies showing that interventions focused on emotional wellness, mindfulness, and adaptive coping can support flexible responses to stress and learning challenges (Hikmat et al., 2025; Razza et al., 2025; Sapulette et al., 2025).

The relationship between physical activity and cognitive flexibility can be interpreted through the combined effects of movement, arousal regulation, executive activation, and emotional balance. Physical activity may improve students' capacity to disengage from rigid patterns of thinking, reduce cognitive fatigue, and increase readiness for problem-solving. Previous studies have reported that sport, exercise, active breaks, and yoga-based programs are associated with better cognitive performance, reduced academic burnout, and improved psychological functioning (Martín-Rodríguez et al., 2024; Ruíz et al., 2025). In addition, studies addressing the integration of physical education into the curriculum have emphasized that movement-based educational

experiences support not only physical development but also discipline, cooperation, self-confidence, emotional regulation, and cognitive adaptation (Habyarimana et al., 2022; Sharma & Upreti, 2023). The present finding therefore reinforces the idea that cognitive flexibility can be cultivated through curriculum experiences that combine mental challenge with bodily engagement.

The third major finding showed that the cognitive science- and physical activity-based curriculum had a significant direct effect on mental health. This result indicates that students who reported greater exposure to such a curriculum also reported better mental health status. This finding is theoretically meaningful because curriculum experiences can influence psychological well-being through several pathways, including increased engagement, improved self-efficacy, reduced academic passivity, stronger peer interaction, emotional regulation, and better stress management. Studies on child and adolescent mental health increasingly emphasize that psychological well-being must be addressed within educational systems rather than only through clinical or remedial services (P. et al., 2024; Subramanyam et al., 2024). The present finding is also consistent with evidence indicating that physical activity has positive effects on students' mental health and can reduce psychological difficulties when implemented at school level (B., 2024; Bagum et al., 2024; Li et al., 2024).

The direct effect of curriculum on mental health can also be understood in relation to the preventive role of school-based interventions. Psychoeducational programs, mindfulness curricula, stress management training, and school counseling approaches have been shown to reduce anxiety, improve mood, and support adaptive psychological functioning among students (Folger et al., 2023; Monsillion et al., 2023; Sevindik & Mansuroğlu, 2025). Moreover, approaches that connect students with nature, wellness, and meaningful educational environments suggest that mental health promotion should be embedded in everyday educational structures rather than treated as an external support service (Greenleaf & Reese, 2024; Vitagliano et al., 2023). In this sense, the present study extends previous findings by showing that a curriculum designed through the combined lens of cognitive science and physical activity may directly contribute to students' mental health within the ordinary school context.

Another important finding was that self-regulated learning significantly predicted mental health. This result suggests that students who are better able to plan, monitor, regulate, and evaluate their learning are also more likely to experience better psychological functioning. Self-regulated learners may experience less academic confusion, lower helplessness, stronger perceived control, and greater ability to manage academic demands. Consequently, self-regulated learning can reduce stress and contribute to more stable mental health. This finding is aligned with studies showing that psychological interventions that strengthen resilience, optimism, mindfulness, and self-management can improve mental health outcomes among students and young people (Barker et al., 2021; Setia et al., 2021). It is also consistent with evidence showing that stress management, mood regulation, and academic adaptation are closely connected to students' academic functioning and psychological adjustment (Cóndor et al., 2024). Therefore, self-regulated learning may be considered both an educational competency and a psychological protective factor.

The finding that cognitive flexibility significantly predicted mental health also deserves attention. Students with higher cognitive flexibility are better able to reinterpret difficulties, generate alternative responses, shift away from unproductive thoughts, and maintain a sense of control in stressful situations. This capacity can reduce anxiety, depressive symptoms, and emotional rigidity. The result is consistent with research showing that emotional wellness supports, mindfulness-based interventions, and resilience-oriented programs help students develop adaptive responses to psychological challenges (Razza et al., 2025; Sapulette et al., 2025). It also corresponds with studies on mental well-being interventions indicating that cognitive-behavioral and digital programs can support psychological functioning by targeting maladaptive thoughts and strengthening coping skills (McCallum et al., 2022; Roberts et al., 2022). In the context of the present study, cognitive flexibility appears to be an important bridge between curriculum experiences and mental health because it enables students to respond more adaptively to academic and emotional demands.

The indirect effects found in the model further clarify how the curriculum may influence mental health. The cognitive science- and physical activity-based curriculum affected mental health both directly and indirectly through self-regulated learning and cognitive flexibility. This means that the curriculum improves students' psychological well-being not only because it provides a more active, supportive, and engaging learning environment, but also because it strengthens internal capacities that help students manage learning and cope with challenges. This finding is consistent with intervention studies showing that multimodal activity breaks, active learning experiences, and well-being

programs can influence mental health by improving emotional regulation, engagement, and adaptive functioning (Argus-Calvo et al., 2024; Marschin & Herbert, 2021). It is also supported by research on online, telehealth, and school psychology interventions showing that educational and psychological supports are most effective when they are structured, accessible, and responsive to students' real learning environments (Baker et al., 2024). Therefore, the mediating roles of self-regulated learning and cognitive flexibility provide a more precise explanation of the curriculum–mental health relationship.

The findings also highlight the importance of addressing sedentary learning patterns in schools. Traditional classroom models often require prolonged sitting, passive listening, and limited opportunities for active cognitive and physical engagement. Such conditions may weaken attention, motivation, emotional balance, and self-regulation. Recent work has emphasized the need to combat youth sedentary lifestyles through practical use of fragmented time and small opportunities for movement throughout the day (Aslam & Bin, 2025). The present study supports this perspective by showing that physical activity, when integrated into a cognitively meaningful curriculum, can be associated with better learning regulation, cognitive flexibility, and mental health. Moreover, studies on school facilities and students' physical factors suggest that institutional and environmental conditions can either support or restrict students' access to movement-based development (Mun, 2021). Thus, curriculum reform should be accompanied by attention to the physical and organizational conditions of schools.

5. Conclusion

Overall, the findings support a multidimensional understanding of curriculum effectiveness. A curriculum based on cognitive science and physical activity can be understood as a developmental framework that connects learning processes with executive functioning, flexible thinking, emotional regulation, and psychological well-being. This approach is consistent with contemporary evidence showing that academic development and mental health are deeply interconnected and that educational systems must adopt integrated strategies to support students' whole-person development (Li et al., 2024; Martín-Rodríguez et al., 2024). The present model contributes to the literature by demonstrating that self-regulated learning and cognitive flexibility are not merely separate student outcomes, but also explanatory mechanisms through which curriculum experiences may influence mental health. Therefore, the study provides empirical support for designing school curricula that move beyond content delivery and intentionally cultivate cognitive, behavioral, physical, and psychological capacities.

The present study had several limitations that should be considered when interpreting the findings. First, the study used a cross-sectional structural equation modeling design; therefore, although the proposed model was theoretically grounded and statistically supported, causal conclusions should be made with caution. Second, the data were collected using self-report questionnaires, which may be influenced by response bias, social desirability, or students' subjective interpretation of questionnaire items. Third, the participants were selected from secondary school students in Tehran, which may limit the generalizability of the findings to students in other cities, rural areas, or different educational systems. Fourth, although the model included important variables such as curriculum, self-regulated learning, cognitive flexibility, and mental health, other relevant factors such as family climate, teacher behavior, peer relationships, socioeconomic status, school resources, academic achievement, and digital media use were not included in the tested model.

Future research should examine, and digital media use were not included in the tested the proposed model using longitudinal, experimental, or quasi-experimental designs in order to provide stronger evidence regarding causal pathways among curriculum design, self-regulated learning, cognitive flexibility, and mental health. It is also recommended that future studies compare different age groups, school levels, and educational districts to determine whether the model functions similarly across diverse student populations. Researchers may also extend the model by including additional mediating and moderating variables such as academic motivation, executive functions, emotional regulation, classroom climate, teacher support, physical fitness, and academic performance. In addition, mixed-methods studies can provide deeper insight into students' lived experiences of cognitive science- and physical activity-based curricula and help explain how specific classroom practices influence learning behavior and psychological well-being.

From a practical perspective, the findings suggest that schools should move toward curriculum designs that intentionally integrate cognitive activation, metacognitive training, feedback-based learning, active participation, and structured physical activity. Teachers should be trained to

use instructional strategies that encourage students to plan, monitor, and evaluate their learning while also providing opportunities for movement, collaborative activity, problem-solving, and reflection. School administrators should support flexible classroom arrangements, active breaks, movement-integrated lessons, and interdisciplinary collaboration between curriculum specialists, educational psychologists, physical education teachers, and school counselors. In practice, such a curriculum should not be implemented as an additional burden or separate program, but as an integrated educational approach embedded in daily teaching and learning activities to promote students' academic self-regulation, adaptive thinking, and mental health.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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Declaration of Interest

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