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Development of the BCELM Learning Model: An R&D Study on Enhancing Critical and Creative Thinking in Madrasah Ibtidaiyah

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ABSTRACT

This study aimed to develop and evaluate the effectiveness of the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM) in enhancing students' critical and creative thinking in Islamic Religious Education (PAI) at Madrasah Ibtidaiyah. The study employed a Research and Development (R&D) approach using the Dick and Carey instructional design model. A preliminary needs analysis was conducted with 22 students, followed by **a** small-class trial involving 24 students and an expanded implementation involving 64 students at MI An-Nizhomiyah Depok. Data were collected through expert validation, classroom observations, critical and creative thinking assessments, and statistical analysis. The findings indicate that BCELM is valid, feasible, and effective for classroom implementation. Regression analysis showed that BCELM had a significant positive effect on students' critical and creative thinking patterns (Sig. = 0.002 < 0.05). In addition, the model improved students' learning engagement, including their interest, attention, participation, and attendance. These findings demonstrate that BCELM provides an effective instructional approach for fostering higher-order thinking skills and improving learning engagement in Madrasah Ibtidaiyah.

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1. INTRODUCTION

Education in contemporary societies faces increasingly complex challenges driven by rapid social change, technological advancement, and shifting cultural values. In Indonesia, these challenges persist as the education system continues to adapt to the dynamic interaction between human development and environmental change. Despite ongoing reforms, improvements in educational quality remain limited, as reflected in Indonesia's relatively low standing in regional and global education indices. Key problems include low teacher income, uneven access to professional certification, limited pedagogical competence, and monotonous instructional practices that fail to foster higher-order thinking skills.

Beyond structural issues, many teachers still lack a deep understanding of education as a meaningful and transformative process. Teaching is often perceived as a secondary career choice rather than a professional vocation, resulting in low pedagogical commitment and minimal participation in professional learning communities such as subject-based teacher forums (MGMP). Consequently, classroom practices remain teacher-centered and repetitive, restricting students' opportunities to develop critical and creative thinking. Over time, these conditions contribute to stagnant educational outcomes.

Addressing these challenges requires innovative learning models that teachers can realistically master and implement. Such models should encourage educators to creatively design strategies, methods, and instructional media that connect learning content with students' cognitive, emotional, and social realities. This need is particularly critical in primary education, where foundational cognitive patterns and learning habits are formed.

In addition to cognitive development, schools play a vital role in shaping students' moral and ethical character. Education involves not only intellectual achievement but also the cultivation of moral values and noble character (Soebahar, 2013). The ultimate aim of moral education is the realization of human goodness and virtue (Supriyatin, 2016), which requires religious consciousness encompassing faith, spiritual experience, attitudes, and religious behavior. As religion engages the totality of human psychological and physical functions, religious consciousness integrates affective, cognitive, conative, and motor dimensions (Ahyadi, 2001). However, moral education increasingly faces challenges as digital media exert a stronger influence on children's psychological development than formal schooling.

In several developed countries, excessive engagement with digital technology has resulted in serious physical and psychological problems among young people, such as online gaming addiction and Computer Vision Syndrome caused by prolonged screen exposure (Bausch & Lomb Incorporated, 2018; Valdani, 2013). These cases underscore the risks of uncontrolled technology use and highlight the urgent need for educational guidance and ethical supervision.

The rapid advancement of digital technology is inevitable and increasingly shapes educational practices. Computers, the internet, and smartphones have become integral to daily life, functioning as a "second self" that supports communication and task completion beyond spatial and temporal boundaries (Atmadja & Ariyani, 2023). In educational contexts, digital devices are difficult to exclude, as students increasingly rely on online resources rather than printed textbooks. Teachers who position themselves merely as transmitters of knowledge risk losing their professional relevance in the digital era (Koesoema, 2015).

Nevertheless, digital technology also offers significant pedagogical opportunities when integrated responsibly. Social media platforms such as Facebook, WhatsApp, Twitter, and Instagram can facilitate instructional communication, assignment submission, and student monitoring. Consequently, educational institutions must integrate digital technology into learning processes while ensuring alignment with pedagogical, ethical, and moral values.

Empirical research indicates a significant shift in how younger Muslim generations acquire religious knowledge. Sakai (2012) found that digital media have become prominent sources of religious learning among Indonesian Muslims. Supporting this finding, research by PPIM UIN Syarif Hidayatullah Jakarta reported that 54.87% of millennia's obtain religious knowledge primarily from online sources, while only 14.31% rely on traditional religious gatherings (Alwahid, 2020). This shift necessitates Islamic education models that integrate digital technology with strong moral and ethical guidance.

From pedagogical and neuroscientific perspectives, learning is fundamentally a physical process involving the formation of new neural connections in the brain. Passive, lecture-based approaches are insufficient for meaningful learning. Instead, effective learning environments emphasize active engagement through facilitation, simulation, games, and role-play (Van Dam, 2013). Brain-friendly learning therefore requires instructional designs that engage students cognitively, emotionally, and

physically. To respond to these challenges, this study adopts a brain-friendly, child-friendly, and environmentally friendly learning model. Instructional media—defined as human, material, or environmental elements that facilitate learning (Bukhari, 2012)—can clarify abstract concepts and enhance understanding (Shemberger, 2014). However, media selection must be carefully guided, as children are highly imitative learners who require adult supervision when engaging with digital content (Haddad, 1992).

Although previous studies have examined digital technology, brain-based learning, and moral education separately, there is limited empirical research integrating these dimensions into a comprehensive instructional model for Islamic Religious Education at the primary school level. Existing studies have generally focused on isolated aspects of learning innovation without providing an integrated framework that simultaneously promotes higher-order thinking, child-centered pedagogy, environmental awareness, and responsible digital engagement within the context of the Merdeka Curriculum. Addressing this gap, the present study develops and evaluates the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM) as an integrated instructional model designed to enhance students' critical and creative thinking while supporting their moral, cognitive, emotional, and environmental development. Specifically, this study aims to compare classroom learning processes under conventional instruction and BCELM implementation, examine students' interest, attention, and participation during learning, analyze improvements in critical and creative thinking, and determine the effectiveness of BCELM in fostering higher-order thinking skills among Madrasah Ibtidaiyah students.

This study addresses the need for an empirically validated instructional model that integrates cognitive, affective, environmental, and digital learning dimensions within Islamic Religious Education. Such an integrated approach is essential to support the effective implementation of the Merdeka Curriculum and to foster students who are critical, creative, ethically responsible, and environmentally conscious. Accordingly, this study contributes to the literature on integrated instructional design for Islamic education while providing teachers and curriculum developers with a practical pedagogical framework for meaningful, student-centered learning in the digital era.

2. METHODS

This study employed a Research and Development (R&D) approach, which is designed to produce an educational product and examine its effectiveness in real instructional contexts. The R&D approach is particularly appropriate for studies aiming to develop, refine, and validate instructional models through systematic and iterative procedures (Sugiyono, 2013). In this research, the R&D method was used to develop a Brain-Friendly, Child-Friendly, and Environmentally Friendly Learning Model for Islamic Religious Education (PAI) at Madrasah Ibtidaiyah An-Nizhomiyah Depok.

To ensure a systematic development process, this study adopted the Dick and Carey instructional design model, which emphasizes goal-oriented instruction, learner analysis, and continuous evaluation throughout the instructional development cycle (Dick et al., 2001).

Development Model and Procedures

The development process followed the sequential stages of the Dick and Carey model, implemented as follows.

The first stage involved identifying instructional goals based on the PAI curriculum and the expected learning outcomes at the Madrasah Ibtidaiyah level. A needs analysis was conducted to identify discrepancies between existing instructional practices and the intended learning outcomes, particularly regarding students' critical and creative thinking skills. Data were collected through classroom observations, teacher interviews, and document analysis of curriculum guidelines and instructional materials. The preliminary needs analysis was conducted in Class B involving 22 students, where the existing conventional instructional practices were observed to identify learning problems and instructional needs.

The second stage consisted of instructional analysis to determine the competencies students were expected to master through PAI learning. Learning objectives were analyzed and categorized into verbal information, intellectual skills, psychomotor skills, and affective competencies, reflecting the holistic characteristics of Islamic Religious Education.

The third stage involved learner analysis to identify students' cognitive, emotional, and social characteristics as the primary users of the developed learning model. This analysis involved 24 students from Class A of MI An-Nizhomiyah, enabling the instructional design to accommodate students' developmental characteristics, learning preferences, and classroom learning needs.

The fourth stage focused on formulating specific instructional objectives. These objectives were expressed in observable and measurable behavioral terms and served as the basis for instructional planning, learning implementation, and assessment.

The fifth stage involved developing assessment instruments to measure students' critical and creative thinking skills. Critical thinking was assessed using structured open-ended and problem-based questions covering analytical thinking, evaluation, interpretation, and logical reasoning. Creative thinking was measured using a performance assessment rubric evaluating fluency, flexibility, originality, and elaboration. Both instruments were validated through expert review to ensure content validity and consistency with the instructional objectives.

The sixth stage consisted of developing instructional strategies that aligned learning objectives, learner characteristics, instructional activities, and assessment methods. The instructional strategies emphasized active learning, collaborative learning, meaningful student engagement, and the responsible integration of digital technology while incorporating brain-friendly, child-friendly, and environmentally-friendly learning principles.

The seventh stage involved developing and selecting the instructional components of the BCELM, including instructional syntax, learning activities, teaching materials, instructional media, classroom management procedures, and environmental learning resources. These components were designed to ensure coherence among instructional objectives, learning strategies, instructional media, and classroom implementation.

The eighth stage focused on formative evaluation through expert judgment. The BCELM was reviewed by experts in instructional design, Islamic education, and educational technology. Their recommendations were used to revise and improve the instructional model before classroom implementation.

The final stage involved revising the instructional model based on the formative evaluation results. The revised BCELM was subsequently implemented in a limited field trial involving 24 students from Class A to examine its practicality and initial effectiveness. Following the successful limited trial, the model was further implemented in an expanded classroom trial involving 64 students from Classes A, B, and C to evaluate its effectiveness and applicability in larger classroom settings. The findings from both implementation stages were used to assess the instructional effectiveness and scalability of the developed learning model.

This study adhered to ethical research standards. Prior to data collection, informed consent was obtained from school authorities, teachers, parents, and students. Participants were informed about the purpose of the study and their right to withdraw at any time. Students' identities were kept anonymous, and all data were used solely for research purposes.

3. FINDINGS AND DISCUSSION

Findings

Classroom Instructional Process under Conventional and BCELM Models

To address the research question concerning how the instructional process differs between conventional learning and the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM), classroom observations were conducted across three instructional settings: small-class conventional learning, small-class BCELM implementation, and large-class BCELM implementation.

The small-class conventional learning trial involved 22 students in Class B at MI An-Nizhomiyah. Observation results indicated that most instructional components were categorized as fair to good. Several initial learning activities, such as apperception and group guidance, achieved only 50% (fair category), suggesting limited student readiness and interaction during early learning stages. In contrast, aspects such as teacher voice clarity, reward provision, assessment determination, lesson summarization, and discussion management reached the very good category. These findings indicate that although the instructional process was generally functional, it remained teacher-centered and required improvement in student engagement and facilitation strategies.

The small-class BCELM implementation, involving 24 students in Class A, demonstrated a clear improvement in instructional quality. Most learning indicators reached good to very good categories, particularly in explaining learning procedures, guiding student collaboration, and managing discussions. This shift reflects the effectiveness of BCELM in fostering a more structured, interactive, and student-centered learning environment aligned with brain-friendly and child-friendly principles.

Further improvement was observed in the large-class BCELM implementation involving 64 students from Classes A, B, and C. Nearly all instructional indicators achieved a 100% score in the very good category, with only the use of learning media and evaluation skills remaining in the good category. These results suggest that BCELM not only maintains instructional quality in larger classes but also demonstrates strong scalability and classroom management effectiveness.

The findings confirm that BCELM produces a substantially more effective instructional process than conventional learning models across both small and large class contexts.

Enhancement of Students' Interest, Attention, and Participation through BCELM Implementation

This section presents the empirical findings related to students' learning engagement following the implementation of the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM). Learning engagement was measured through four indicators, namely interest, attention, participation, and attendance, across three learning settings: small-class conventional model, small-class BCELM model, and large-class BCELM model. The comparative results are summarized in Table 1.

Table 1. Students' Learning Engagement across Learning Models

No	Assessment Indicator	Small Class – Conventional Model		Small Class – BCELM Model		Large Class – BCELM Model	
		Score (%)	Level	Score (%)	Level	Score (%)	Level
1	Interest	76%	Good	88%	Good	97%	Very Good
2	Attention	80%	Good	90%	Good	94%	Very Good
3	Participation	78%	Good	92%	Good	97%	Very Good
4	Attendance	78%	Good	90%	Good	97%	Very Good

As shown in Table 1, students' learning engagement demonstrates a consistent improvement across all indicators following the implementation of the BCELM, particularly through the BCELM model. In the small-class conventional learning setting, all engagement indicators were categorized as *Good*, with percentage scores ranging from 76% to 80%. These results indicate a moderate level of student engagement under traditional instructional conditions.

A noticeable increase was observed in the small-class BCELM model, where students' engagement improved across all indicators. Interest increased to 88%, attention to 90%, participation to 92%, and

attendance to 90%, all remaining within the *Good* category but showing substantial quantitative gains compared to the conventional model. This finding suggests that the integration of brain-friendly, child-friendly, and environmentally-friendly principles contributes positively to students' active involvement in learning.

The highest level of engagement was achieved in the large-class BCELM model, where all indicators reached the *Very Good* category. Interest, participation, and attendance each recorded a score of 97%, while attention reached 94%. These results indicate that the BCELM is not only effective in small-class settings but also highly adaptable and impactful in large-class environments. The learning model appears to successfully foster students' motivation, focus, active participation, and consistent attendance, even in classrooms with a larger number of students.

These findings provide empirical evidence that the BCELM significantly enhances students' learning engagement, which serves as a critical foundation for the development of critical and creative thinking patterns in Madrasah contexts.

Enhancement of Students' Critical and Creative Thinking Patterns through BCELM

The implementation of the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM) was associated with notable improvements in students' critical and creative thinking patterns across different instructional settings. Students' thinking patterns were analyzed by comparing outcomes from small-class conventional learning, small-class BCELM Model , and large-class BCELM implementation.

The findings indicate a clear upward trend in higher-order thinking skills following the adoption of BCELM, with improvements observed consistently across both critical and creative dimensions.

Table 2. Students' Critical and Creative Thinking Patterns across Learning Models

No.	Thinking Pattern	Small Class – Conventional Model (%)	Category	Small Class – BCELM Model (%)	Category	Large Class – BCELM Model (%)	Category
1	Critical Thinking	55	Moderate	80	Good	94	Very Good
2	Creative Thinking	77	Good	90	Good	97	Very Good

As shown in Table 2, the implementation of different learning models and class sizes is associated with varying levels of students' engagement and cognitive performance. The table summarizes students' critical and creative thinking patterns under the conventional model and the BCELM model , highlighting progressive improvements in learning outcomes as the instructional model shifts toward a more brain-friendly, child-friendly, and environmentally-friendly framework. Students' critical thinking patterns under the small-class conventional learning model reached 55%, corresponding to a fair level. Following the implementation of BCELM in small-class settings, the critical thinking score increased substantially to 80%, indicating a good level of performance. A further improvement was evident in large-class BCELM implementation, where critical thinking reached 94%, classified as very good.

A comparable pattern emerged in creative thinking outcomes. Creative thinking in the conventional model achieved 77%, categorized as good. The application of BCELM in small-class learning increased this score to 90%, reflecting stronger creative engagement. The highest creative thinking score (97%, very good) was observed in large-class BCELM implementation. These results demonstrate that BCELM contributes meaningfully to the enhancement of students' higher-order thinking skills. The strong performance observed in large-class settings suggests that the model remains effective even when applied in learning environments with higher instructional complexity.

Effect of the BCELM on Students' Critical and Creative Thinking Patterns

To examine the effect of the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM) on students' critical and creative thinking patterns, a regression analysis was conducted. This analysis aimed to determine the extent to which the implementation of BCELM contributes to variations in students' critical and creative thinking outcomes. The results of the regression analysis are presented in Table 3 below.

Table 3 Regression Analysis of BCELM Learning on Students' Critical and Creative Thinking Patterns

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	68.130	12.023	—	5.667	.000
BCELM Learning Model	0.218	0.064	0.539	3.387	.002
Dependent Variable: Critical and Creative Thinking Patterns					

Based on the regression analysis, the following regression equation was obtained:
Y = 68.13 + 0.218X

The regression equation indicates that the constant value of 68.13 represents the level of critical and creative thinking patterns when the independent variable is held constant (X = 0). The regression coefficient of 0.218 suggests that for every one-unit increase in brain-friendly, child-friendly, and environmentally friendly digital technology-based learning, critical and creative thinking patterns increase by 0.218 units. The partial test (t-test) results show that the independent variable has a t value of 3.387 with a significance value of 0.002, which is lower than the predetermined significance level (α = 0.05). This result indicates that brain-friendly, child-friendly, and environmentally friendly digital technology-based learning has a positive and statistically significant effect on critical and creative thinking patterns.

Furthermore, the Model Summary reveals a correlation coefficient (R) of 0.539, indicating a moderately strong relationship between the independent and dependent variables. The R Square value of 0.291 implies that 29.1% of the variance in critical and creative thinking patterns is explained by brain-friendly, child-friendly, and environmentally friendly digital technology-based learning, while the remaining 70.9% is influenced by other factors not included in this research model.

These findings demonstrate that brain-friendly, child-friendly, and environmentally friendly digital technology-based learning contributes significantly to the enhancement of students' critical and creative thinking patterns.

3.2. Discussion

The Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM) is rooted in neuroscience-based learning theory, which emphasizes that learning effectiveness is closely related to emotional states, physical conditions, and environmental stimuli. As Jensen (2008a) asserts, emotional reactions trigger chemical processes in the brain that directly influence attention, memory, and reasoning. In this sense, learning is not merely a cognitive activity but a holistic neurological process involving emotional, physiological, and environmental interaction. Recent developments in educational neuroscience further reinforce the conceptual foundation of BCELM by emphasizing that meaningful learning emerges from the dynamic interaction between cognitive processing, emotional regulation, and active engagement within supportive learning environments. This perspective strengthens the brain-friendly dimension of BCELM, in which instructional activities are intentionally designed to stimulate neural connections through emotionally positive, multisensory, and inquiry-oriented learning experiences rather than passive knowledge transmission (Winantaka, 2024).

Likewise, the conceptual framework of brain-based learning proposed by Dwiprabowo et al. (2024) argues that instructional experiences encouraging critical thinking facilitate memory consolidation and knowledge retrieval because learners actively construct understanding through reasoning and reflection.

Furthermore, the child-friendly principles embedded in BCELM are consistent with contemporary educational neuroscience, which highlights that psychologically safe learning environments, learner autonomy, and supportive teacher–student relationships optimize brain functioning while promoting cognitive and socio-emotional development (Dettweiler et al., 2023). From the environmental perspective, BCELM also reinforces recent educational theory asserting that authentic interaction with natural environments provides meaningful contexts that stimulate curiosity, creativity, and higher-order thinking through experiential learning processes (Falzon & Conrad, 2024). Collectively, these theoretical perspectives provide a strong conceptual justification for BCELM as an integrated instructional model that harmonizes brain-based learning, child-centered pedagogy, and environmental engagement to optimize students' critical and creative thinking.

Neuroscientific research further confirms that the human brain continuously reorganizes itself through neuroplasticity, particularly during early developmental stages when learning experiences at home and school play a decisive role in shaping neural circuits (Sousa, 2009). Scientific evidence also demonstrates that neurons are capable of regeneration, thereby strengthening memory and learning capacity (Sousa, 2009). These findings provide a theoretical justification for BCELM, which prioritizes meaningful learning experiences, emotional safety, and active engagement.

BCELM also acknowledges neurological variations among learners. Although male and female learners may show tendencies toward different cognitive strengths, such as verbal or spatial abilities, these differences occur within overlapping distributions rather than fixed categories (Jensen, 2008a). Accordingly, BCELM promotes inclusive instructional strategies that accommodate diverse cognitive processing styles without reinforcing stereotypes.

Physical activity is an essential component of brain-friendly learning. Regular movement enhances blood circulation, increases oxygen and nutrient supply to the brain, stimulates growth factors, and improves dopamine production, which positively affects mood and motivation (Jensen, 2008a). Empirical findings by Van Praag, Christie, Sejnowski, and Gage further demonstrate that physical activity stimulates neurogenesis and extends neuronal survival. These findings explain why BCELM integrates active learning strategies to maintain students' cognitive readiness and emotional balance.

Recent studies have further demonstrated that integrating structured physical activity into classroom instruction contributes not only to students' physical well-being but also to the development of higher-order cognitive abilities (Guzmán-Muñoz et al., 2025). Physical activity has been consistently associated with improvements in executive functions, including inhibitory control, working memory, and cognitive flexibility, which serve as fundamental prerequisites for critical and creative thinking (Sember et al., 2020). Furthermore, movement-based learning environments have been found to enhance students' attention, self-regulation, and academic performance by increasing engagement throughout the learning process (Guzmán-Muñoz et al., 2025). Collectively, these findings provide robust empirical support for the BCELM framework, which intentionally integrates brain-friendly, child-friendly, and environmentally-friendly learning experiences to optimize cognitive readiness, emotional well-being, and creative problem-solving among Madrasah Ibtidaiyah students (Steckenleiter, 2025).

Stress regulation is another central element of the BCELM framework. Stress is understood as a subjective perception rather than an objective condition, and excessive stress can significantly impair learning processes. Teachers therefore play a strategic role in managing classroom climates that reduce distress while maintaining productive challenge (eustress) (Jensen, 2008b). Emotionally supportive teaching practices and positive learning environments contribute to healthier stress responses and improved learning outcomes (Jensen, 2008b).

Beyond creating emotionally supportive classrooms, the broader school environment also plays a crucial role in fostering students' emotional regulation. A school climate characterized by fairness and institutional justice strengthens students' capacity to regulate emotions, primarily through the supportive relationships established with teachers (Yang & Liu, 2026). Teacher support functions as the most influential mechanism linking perceptions of school justice to emotional regulation, while peer support provides an additional, complementary pathway by reinforcing the positive effects of teacher–student relationships (Frenzel et al., 2021). These findings underscore that emotionally supportive teachers, positive peer interactions, and a fair school environment collectively enhance students' emotional regulation skills, thereby creating conditions that are conducive to effective learning and consistent with the principles underpinning the BCELM framework (Ahnert et al., 2012).

Environmental conditions also influence cognitive performance. Poor physical environments—such as inadequate lighting, overcrowding, poor ventilation, and damaged facilities—negatively affect attention and information processing. In contrast, brain-friendly environments provide proper lighting, acoustics, ventilation, temperature regulation, and visually supportive spaces (Jensen & Nickelsen, 2008). Nutritional intake and hydration further support cognitive balance and stress regulation (Jensen & Nickelsen, 2008). These principles are operationalized within BCELM through structured classroom management and attention to students' physical well-being.

The child-friendly dimension of BCELM is based on the assumption that every child possesses inherent potential that must be nurtured through emotionally supportive learning environments. Traditional intelligence measures are insufficient to capture the diversity of human abilities. Gardner's theory of Multiple Intelligences identifies various forms of intelligence, including linguistic, logical-mathematical, visual-spatial, musical, kinesthetic, naturalistic, emotional, and interpersonal intelligences (Wijanarko & Setiawati, 2017). Learning experiences characterized by joy, enthusiasm, and emotional safety are more likely to be stored in long-term memory and support holistic development (Sears et al., 2006).

Parental involvement further strengthens child-friendly learning. Fitriani (2017) emphasizes recognizing children's innate potential, modeling positive behavior, and providing consistent guidance through patience and affection. Wijanarko & Setiawati (2017) similarly highlight the importance of positive and nurturing environments, while Murdoko (2007) stresses the responsibility of parents in shaping foundational character traits. Within BCELM, these principles are operationalized through school–parent collaboration, parenting assistance programs, counselor readiness, and partnerships with child protection institutions.

Recent evidence further reinforces the importance of structured family–school partnerships as a fundamental component of child-friendly learning environments. Such reciprocal partnerships create consistency between children's learning experiences at home and at school, enabling the development of stronger socio-emotional competencies and greater engagement in learning (Paccaud et al., 2021). Furthermore, parents who maintain regular communication with teachers are better able to provide learning support that complements classroom instruction, thereby strengthening children's motivation, emotional security, and learning persistence. Family involvement in early childhood education is a cornerstone of the educational process, significantly influencing children's holistic development and fostering stronger connections within the school community (Otero-Mayer et al., 2025). These findings are highly consistent with the BCELM framework, which positions parents as active educational partners rather than passive recipients of school programs. Consequently, systematic collaboration among schools, families, counselors, and community-based child protection services provides an integrated support system that simultaneously promotes brain-friendly learning, child well-being, and environmentally responsive educational practices, thereby enhancing children's holistic cognitive, emotional, and social development (Paccaud et al., 2021).

The effectiveness of family involvement also depends on how schools create meaningful opportunities for parents to participate in the educational process rather than assuming that parental engagement will emerge naturally. Previous research indicates that differences in parental involvement

are influenced not only by family characteristics but also by the extent to which schools establish supportive communication, mutual trust, and collaborative partnerships with parents (Pusztai et al., 2023). This perspective is highly relevant to the BCELM framework, which emphasizes that brain-friendly and child-friendly learning cannot be achieved solely through classroom practices but requires sustained collaboration between schools and families. Therefore, structured school–parent partnerships within BCELM provide a supportive ecosystem that reinforces children's cognitive development, emotional security, and positive learning behaviors across both home and school contexts.

The environmentally-friendly component of BCELM aligns with environmental education initiatives such as the Adiwiyata program. Adam (2014) demonstrates that effective environmental education requires institutional commitment, regulatory support, stakeholder collaboration, and sustained implementation. Environmental health issues, including exposure to unsafe food and pesticides, have been linked to digestive disorders and stunting, which negatively affect cognitive and physical development (Rosida & Windraswara, 2017; Utami et al., 2013). BCELM integrates environmental education with Islamic values derived from the Qur'an and Hadith to strengthen students' moral responsibility toward environmental sustainability.

Critical thinking involves rational inquiry, reflective reasoning, and evidence-based decision-making (Asmani, 2013; Rochaminah, 2008). Ennis' framework highlights essential components such as clarification, inference, evaluation, and integration (Maftukhin, 2013). BCELM supports these processes by creating emotionally safe, cognitively stimulating, and student-centered learning environments. Creative thinking, characterized by fluency, flexibility, originality, and elaboration (Baer, 1993; Perkins, 1985), is similarly fostered through opportunities for exploration and idea generation (Jayadiputra, 2015; Marzano, 1988). The findings indicate that students exposed to BCELM demonstrate improved critical and creative thinking patterns.

This study has several limitations. First, the research was conducted in a single madrasah context, which may limit the generalizability of the findings to other educational settings. Second, the implementation period of the BCELM was relatively limited, restricting the ability to observe long-term effects on students' cognitive and character development. Third, the study focused primarily on critical and creative thinking skills, while other important outcomes such as collaborative skills and academic achievement were not examined in depth.

4. CONCLUSION

Based on the results of the development, implementation, and evaluation of the Brain-Friendly, Child-Friendly, and Environmentally-Friendly Learning Model (BCELM), the main conclusions of this study are as follows:

BCELM is an effective instructional model for enhancing students' critical and creative thinking patterns in Madrasah education. The model aligns well with neuroscientific learning principles, child-centered pedagogy, and environmentally-oriented learning practices within a digital learning context.

The implementation of BCELM creates a supportive, engaging, and inclusive classroom environment, particularly in large-class settings. Classroom observations show that students taught using BCELM demonstrate higher levels of problem analysis, idea generation, originality, and solution elaboration compared to students experiencing conventional instruction.

Regression analysis confirms that BCELM significantly predicts students' critical and creative thinking outcomes, indicating that consistent application of brain-friendly, child-friendly, and environmentally-friendly instructional practices contributes meaningfully to the development of higher-order thinking skills.

The effectiveness of BCELM is driven by its holistic pedagogical structure, in which emotional regulation, sensory engagement, and cognitive diversity (brain-friendly), emotional safety and student participation (child-friendly), and contextual relevance through environmental awareness (environmentally-friendly) are systematically integrated into instructional activities.

Teachers are encouraged to integrate BCELM principles into daily lesson planning, particularly by designing learning activities that actively engage students emotionally, cognitively, and physically. In large-class contexts, BCELM can be applied to enhance student participation and interaction through collaborative learning, varied sensory stimuli, and contextual problem-solving tasks. Schools and Madrasah Ibtidaiyah administrators may use BCELM as a reference framework for instructional improvement, especially in digitally supported learning environments that aim to foster critical and creative thinking skills.

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