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The Impact of AI on the Cognitive Development of Children Aged 6-12 in low exposure contexts: a Case Study in Bangladesh

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1.0 Abstract

Ages 6-12 represent a critical period for children's development of thinking skills, creativity, learning ability and cognitive skills. During these years, the prefrontal cortex matures rapidly, supporting decision-making, planning, self-regulation and the drastic improvement of fundamental skills like cognitive adaptability, and active memory. Therefore, introducing them with AI tools during this sensitive period may have lasting impacts on their learning skills and behavior.

While the effects of artificial intelligence (AI) have been studied in various contexts, limited research has focused specifically on young children during this crucial brain developmental stage. This research aims to assess whether integrating AI tools into the education system during this critical period supports or hinders cognitive growth in children aged 6-12. A study will be conducted involving three groups of students: (1) Group receiving AI-assisted learning with structured training, (2) Group granted with unstructured AI access with no guidance, and (3) Control group with no AI exposure. Participants will be assessed before and after the intervention using comprehensive and multidimensional approaches. Assessment measures will include standardized cognitive and problem-solving tests, academic performance measures, creativity and IQ assessments, real-world task execution evaluation, and structured interviews with students, their parents, and their teachers. Parental consent and ethical guidelines will be strictly observed throughout the study.

The findings of this study will provide evidence-backed guidelines for policymakers and educators to make informed decisions on incorporating AI technologies in early education.

2.0 Introduction

Artificial Intelligence has become a transformative force across many sectors including the educational sector. AI-driven tools such as adaptive learning platforms, intelligent tutoring systems, and chatbots have enabled students to access personalized learning pathways [1], [2]. Given its potential benefits and risks, it is important to exercise caution in AI's usage, especially for children aged 6 to 12. During this age, the prefrontal cortex matures rapidly which regulates the executive functions such as decision-making, self-regulation, and working memory [3], [4]. Emotional and social development also progress and children learn to better understand others' perspectives and manage their own emotions [5]. Therefore, it is important to determine whether the use of AI for learning during the ages of 6 to 12 years facilitates or hinders their cognitive development, and to assess whether introducing AI at such an early stage is advisable. Although much research has been conducted on the effect of AI-assisted learning, most of the studies focused on more mature age groups. Very limited research has been conducted on children aged 6 to 12, during the crucial period of brain development. Bangladesh faces challenges in accessing technology, especially at the primary education level since it has limited digital infrastructure and device availability [6], [7]. Since integration of AI in Bangladeshi primary schools is still rare, this provides a unique opportunity to assess the impact of AI-assisted learning in children aged 6 to 12 in a low AI exposure environment, yielding fresh and reliable results.

3.0 Literature Review

3.1 Previous Research: AI is known to have a substantial role in transforming the education sector by providing personalized and adaptive learning experiences, increasing student engagement, and automating tasks [1]. It has been found that intelligent tutoring systems that adapt to the learner's pace improve learning outcomes when aligned with the curricula [2]. Usage of AI for learning in primary education has shown promise in promoting creativity, conceptual understanding, and motivation among children. However, AI-assisted learning also has potential drawbacks such as over-dependence leading to reduced critical thinking skills [8]. In Bangladesh, AI integration in primary education is still in its beginning stages although there has been growing interest in this field [7].

3.2 Research Gaps: Despite the growing number of studies conducted on the impact of AI-assisted learning, most of the research focuses more on older learners, leaving significant gaps regarding children aged 6 to 12 during the critical period of their cognitive development. Moreover, most existing studies focus on the short-term academic outcomes, with limited assessment of long-term effects of AI-assisted learning on cognitive skills, creativity, and independent learning skills during early education. There is a lack of research in low-resource regions like Bangladesh that have limited exposure to AI due to limited infrastructure. While AI improves learners' engagement by providing personalized learning experiences, concerns about over-reliance potentially hampering cognitive development in young learners are understudied. Additionally, there is a lack of research comparing the effects of structured versus unstructured AI usage in primary education, which is essential to understand how to utilize different AI learning models. Addressing these concerns is essential to decide whether AI-assisted learning is truly beneficial.

4.0 Research Questions

1. How does structured AI use, unstructured AI use, and no AI use affect problem-solving ability, creativity, and attention span in young children?
2. How does using AI for learning influence children's willingness and ability to engage with academic topics by themselves?
3. With different modes of AI use (structured vs unstructured), to what extent do children use AI as a helpful tool to better understand academic concepts versus merely generating answers, and how does this affect their learning strategies?
4. How do different modes of AI-assisted learning (structured vs unstructured) impact short-term academic performance, long-term retention of knowledge, and independent study habits in young children compared to traditional learning?

5.0 Methodology

5.1 Research Design: This study will be using a mixed-method approach combining both qualitative and quantitative approaches to evaluate the impact of AI-assisted learning on the cognitive development of children aged 6-12. Pre-test/post-test design will be used for quantitative data collection. Quantitative data will primarily be analyzed using Linear Mixed-Effects Models (LMM), with supplementary ANOVA and post-hoc tests (Tukey's HSD). Thematic analysis will be used to analyze qualitative data. The participating students will be divided into three groups: (1) Group receiving AI-assisted learning with structured training, (2) Group granted with unstructured AI access with no guidance, and (3) Control group with no AI exposure.

5.2 Sample: Sample consists of 500 children (N=500) aged 6-12, from grades 1 to 6, randomly selected from both private and public schools in Dhaka, Bangladesh. For balanced representation, the sample will include an approximately equal number of students from each grade and gender.

Inclusion Criteria: Children aged 6-12 with minimal or no prior exposure to AI learning tools.

Exclusion Criteria: Children diagnosed with learning or development disorders.

5.3 Assessment Measures:

a. Academic Performance: Standardized grade level tests.

b. Cognitive Skills: Age-appropriate problem solving tasks, IQ tests, pattern recognition tests, and working memory tests.

c. Teacher Observation Report: Participation in class including engagement, creativity, and critical thinking.

d. Parent Observation Report: Changes in curiosity, self-learning, and homework habits.

5.4 Data Collection

Quantitative Data: Pre-test and post-test assessments will include the mentioned cognitive tests, academic performance tests, and creativity tests.

Qualitative Data: Interviews with parents and teachers will document observed changes in each child's learning habits, problem-solving ability, creativity, attention, and AI usage.

5.5 Data Analysis:

Independent Variables (IVs): Type of AI access: Structured access with proper training, Free unstructured access with no training, no access to AI.

Dependent Variables (DVs): Academic performance, age-appropriate problem solving skills, IQ test scores, pattern recognition ability, working memory, creative and critical thinking, engagement in class, homework habits, and self-learning ability.

Quantitative Analysis: Pre- and post-intervention test scores for each DV will be analyzed primarily using Linear Mixed-Effects Models (LMM) which account for repeated measures, and covariates such as socio-economic background, gender, and grade level. For enhanced transparency, repeated-measures ANOVA test may also be run as a supplementary check to

compare differences across the three groups. If major differences are found, post-hoc tests (Tukey's HSD) will be used to identify which groups differ for each DV.

Qualitative Analysis: Interviews with the students, guardians, and teachers will be analyzed using thematic analysis to find patterns in observed changes in children in terms of their learning and problem-solving ability, critical and creative thinking, attention span, ability to perform daily tasks, and how the children are utilizing AI.

5.6 Ethical Consideration: Prior to data collection, ethics approval will be obtained from an Institutional Review Board. Guardians will provide written consent and children will provide their verbal consent in age-appropriate language. Participants' privacy will be protected; participation is voluntary, and children may withdraw at any moment without any penalty. To avoid added pressure, the regular routines of the children will be maintained.

5.7 Timeline:

6 month research timeline

Month 0: Pre-intervention Assessment

a. Carry out all the starting assessments that test problem-solving, creativity, IQ, school performance, and real-world tasks.

b. Hold interviews with students, guardians, and teachers.

c. Collect consent forms from guardians and school authorities.

Month 1-4: Intervention Period

a. Participants continue with their schoolwork as usual.

b. They interact with AI as planned.

c. Researchers ensure the participants are adhering to the rules and regulations.

Month 2: Midpoint Check

a. Check progress and ensure that the plan is followed.

Month 5: Post-intervention assessment

a. Repeat all the tests to measure changes in problem-solving, creativity, attention, school performance, and real-life task execution.

b. Repeat interviews with the participating students, their parents, and teachers.

Month 6: Data Analysis and Reporting

a. Analyse test scores using Linear Mixed-Effects Models (LMM).

b. For increased transparency, run repeated-measures ANOVA tests to compare changes across the three groups.

c. If differences are found between the groups, run post-hoc tests (Tukey's HSD).

d. Summarise findings and write the final report.

6.0 Conclusion

This study aims to explore the effects of AI-assisted learning on the cognitive growth of children aged 6 to 12 during the crucial period of their brain development. By investigating the effects of structured versus unstructured AI usage in low exposure regions such as Bangladesh, this study aims to provide early insights into how AI-assisted learning in primary education impacts cognitive growth, creative thinking, academic performance, critical

thinking, and independent learning. The findings of this study will offer valuable guidance for policymakers and educators for the effective use of AI in early education.

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