# EFFECTIVENESS OF CRITICAL THINKING SKILLS FOR DEVELOPING ARITHMETIC AMONG CHILDREN WITH HEARING IMPAIRMENT: A LITERATURE REVIEW

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**Abstract**

The development of arithmetic skills is a crucial aspect of cognitive and academic growth, particularly for children with hearing impairment (CWHI). Unlike their hearing peers, these children face unique challenges in mathematical comprehension due to language and communication barriers, which can hinder their ability to grasp arithmetic concepts. Critical thinking (CT) skills play a pivotal role in overcoming these challenges, as they facilitate logical reasoning, problem-solving, and systematic analysis. This literature review explores the significance of CT in mathematical learning for children with hearing impairment, examining existing research on CT-based interventions and their impact on arithmetic skill development. The paper further discusses various educational strategies, theoretical frameworks, and empirical studies related to CT and mathematics learning among children with hearing impairment. The findings indicate that CT-based approaches significantly enhance numerical comprehension and problem-solving abilities, providing a strong foundation for further mathematical education. This review concludes by identifying research gaps and proposing future directions for effective educational interventions.

**Keywords:** Critical Thinking (CT), Arithmetic Learning, Children with Hearing Impairment (CWHI), and Problem-Solving

## Introduction

Mathematics is a fundamental subject that forms the basis of logical reasoning and problem-solving skills necessary for everyday life. While typically developing children acquire arithmetic skills through language-based learning and real-world experiences, children with hearing impairment often face difficulties due to their limited access to auditory information. Research suggests that the primary challenge in arithmetic learning for children with hearing impairment is not their hearing impairment itself, but rather their cognitive processing of mathematical concepts due to linguistic delays (Nunes& Moreno, 2002). This issue necessitates alternative learning approaches that emphasize CT skills.

CT is defined as the ability to analyze, evaluate, and systematically solve problems. It is essential in mathematics education as it promotes deeper understanding, logical structuring of information, and effective problem-solving strategies (Facione, 1990). Several studies have explored the role of CT in enhancing mathematics learning, particularly for children with special needs (Paul & Elder, 2006). This paper reviews the existing literature on CT-based mathematical interventions for children with hearing impairment, highlighting the effectiveness of structured critical thinking frameworks in arithmetic skill development.

## Review of Literature

### *Theoretical Frameworks on Critical Thinking and Arithmetic Learning*

#### *Piaget's Cognitive Development Theory*

Jean Piaget (1952) proposed that children progress through four stages of cognitive development: sensorimotor, preoperational, concrete operational, and formal operational. Arithmetic learning, particularly for Children with Hearing Impairment (CWHI), is most relevant during the concrete operational stage (ages 7–11) when children develop logical thinking, understand conservation, and apply reasoning to solve problems.

For children with hearing impairment, the absence of auditory input may lead to delays in acquiring number concepts and problem-solving skills. Therefore, instructional strategies that incorporate hands-on activities, visual aids, and interactive problem-solving tasks can foster conceptual understanding. CT-based interventions aligned with Piagetian principles encourage deeper engagement by promoting structured exploration, hypothesis testing, and reflection during numerical problem-solving.

Application to children with hearing impairment:

- Use of manipulatives and visual models (e.g., counting blocks, diagrams) to support understanding of number relationships.
- Encouraging peer collaboration to enhance reasoning and verbalization of mathematical ideas.
- Incorporation of self-reflection and metacognitive strategies to promote systematic thinking and abstraction.

***Vygotsky's Sociocultural Theory***

Lev Vygotsky (1978) emphasized that learning is a socially mediated process where knowledge is constructed through interaction with more knowledgeable others. His concept of the Zone of Proximal Development (ZPD) highlights the gap between what a child can do independently and what they can achieve with guidance. For children with hearing impairment, leveraging the ZPD through scaffolding, guided practice, and interactive problem-solving can bridge this gap and accelerate arithmetic skill development.

***Application to children with hearing impairment:***

- *Collaborative learning* using peer tutoring, group work, and teacher-led discussions to build understanding.
- *Use of sign language, visual aids, and assistive technologies* to facilitate interaction and engagement.
- *Problem-based learning (PBL)* scenarios that encourage exploration and critical analysis of mathematical problems.

***Role of Mediators***

- *Teachers and peers* serve as facilitators who provide meaningful prompts and cues to guide mathematical reasoning.
- *Visual-spatial tools* such as charts, diagrams, and real-life problem contexts support cognitive processing and enhance numerical understanding.

**Paul and Elder's Critical Thinking Model**

Paul and Elder (2006) outline a comprehensive framework for critical thinking that consists of *eight essential elements*:

1. Purpose: Understanding the objective of the task or problem.
2. Question at Issue: Defining the core problem to be addressed.
3. Information: Gathering relevant data and evidence.
4. Concepts: Applying mathematical theories and principles.
5. Assumptions: Recognizing underlying assumptions.
6. Interpretation and Inference: Drawing logical conclusions.
7. Implications and Consequences: Evaluating the effects of decisions.
8. Point of View: Considering alternative perspectives.

**Application to Arithmetic Learning:**

- Analyzing word problems to identify key information and define the problem accurately.
- Evaluating problem-solving approaches to determine the most effective strategy.
- Applying logical reasoning to develop systematic solutions and verify outcomes.
- Encouraging reflection to assess alternative solutions and refine mathematical understanding.

**Challenges Faced by Children with Hearing Impairment in Arithmetic Learning**

***Numerical Conceptualization***

Children with hearing impairment often encounter difficulties understanding numbers, values, and sequences due to reduced exposure to auditory-based learning experiences. Their delayed acquisition of symbolic representation and numerical reasoning can result in challenges with basic arithmetic operations and number sense (Marschark& Spencer, 2010).

**Potential Solutions**

- *Visual models and tactile tools* to develop number sense and reinforce numerical relationships.
- *Multimodal instructional approaches* that combine visual, kinesthetic, and experiential learning to enhance understanding.

**Word Problem Comprehension**

Word problems require the integration of linguistic comprehension and mathematical reasoning.Children with hearing impairmentmay struggle to extract relevant information due to limited exposure to verbal language, leading to challenges in transforming word problems into mathematical expressions (Kelly & Gaustad, 2006).

**Potential Solutions**

- Visual representation of problems (e.g., diagrams, flowcharts) to facilitate comprehension.
- Sign language or written explanations to clarify problem contexts and guide mathematical reasoning.

**Mental Arithmetic Skills**

Mental arithmetic relies on auditory memory and quick numerical processing, which are areas where children with hearing impairmentmay face limitations due to a lack of auditory input (Nunes& Moreno, 2002). As a result, they often rely on visual or manual calculation strategies, slowing down their problem-solving process.

**Potential Solutions:**

- Use of visual mnemonic devices to reinforce number patterns and operations.
- Development of alternative cognitive strategies such as finger counting, visual grouping, and chunking techniques.

**Empirical Studies on Critical Thinking and Arithmetic Skill Development**

***The Role of Problem-Solving in Mathematics Learning***

Empirical research underscores the importance of **problem-solving approaches** in enhancing arithmetic learning outcomes:

- Runisah et al. (2017) demonstrated that structured problem-solving techniques significantly improve arithmetic proficiency in children with learning disabilities by encouraging systematic exploration and analysis of problems.
- Rasiman (2015) emphasized the role of CT in developing mathematical reasoning skills, with findings indicating that students who engage in logical analysis and reflection perform better in arithmetic tasks.
- Halpern (1998) argued that CT enhances numerical reasoning by promoting analytical thinking and systematic evaluation, leading to more effective problem-solving outcomes.

**Mathematical Cognition in Deaf Learners**

Studies exploring mathematical cognition among deaf learners highlight the need for innovative instructional strategies:

- Swanwick& Watson (2005) advocated for the use of visual models, problem-based learning, and peer collaboration to enhance mathematical comprehension among deaf students.
- Pagliaro&Kritzer (2013) found that deaf students perform better in arithmetic when exposed to visual problem-solving methods that promote active engagement and conceptual understanding.

**Effectiveness of Critical Thinking-Based Interventions**

CT-based interventions have been shown to significantly improve arithmetic learning outcomes for children with hearing impairment:

- Lang & Pagliaro (2018) investigated the impact of inquiry-based learning in mathematics instruction for children with hearing impairment, revealing improved numerical comprehension and problem-solving skills.
- Hong Kong University (2017) outlined the key CT components analysis, reasoning, and problem-solvingthat contribute to mathematical success among students with

special needs.

- Ennis (2011) emphasized that structured CT frameworks lead to significant improvements in arithmetic performance by enhancing students' ability to critically assess and solve mathematical problems.
- Hyde, Zevenbergen, & Power (2003) examined numeracy development in deaf students, demonstrating that CT-based approaches facilitate better learning outcomes and sustained mathematical understanding.

**CONCLUSION**

The review of literature highlights the critical role of theoretical frameworks in shaping arithmetic learning outcomes for Children with Hearing Impairment (CWHI). Piaget's Cognitive Development Theory emphasizes the importance of structured, stage-appropriate learning that progresses from concrete to abstract reasoning, underscoring the need for hands-on, visual-based instructional strategies to facilitate numerical understanding. Vygotsky's Socio-cultural Theory reinforces the significance of social interaction and scaffolding in promoting cognitive growth, particularly through collaborative learning and guided problem-solving within the Zone of Proximal Development (ZPD). Moreover, Paul and Elder's Critical Thinking (CT) Model provides a structured approach to developing analytical, evaluative, and problem-solving skills that are essential for arithmetic success.

The challenges faced by CWHI, including numerical conceptualization, word problem comprehension, and mental arithmetic skills, highlight the need for innovative, multi-sensory teaching methods that go beyond traditional rote learning. Studies consistently demonstrate that CT-based interventions such as inquiry-based learning, problem-solving strategies, and visual problem representation enhance mathematical reasoning and problem-solving capabilities in CWHI. Empirical evidence from studies by Runisah et al. (2017), Rasiman (2015), and Lang &Pagliaro (2018) further underscores the effectiveness of CT approaches in fostering mathematical proficiency and boosting arithmetic performance.

Given the empirical support for integrating CT into arithmetic instruction, it is evident that a multidimensional, student-centered approach that blends CT principles with visual, interactive, and collaborative techniques can bridge learning gaps for CWHI. Moving forward, educators should prioritize the implementation of CT-based instructional strategies

to foster deeper mathematical comprehension and enhance overall learning outcomes for CWHI.

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