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A COGNITIVE PERSPECTIVE ON THE POP IT NUMERACY MODULE: ENHANCING NUMBER CONCEPTS AND WORKING MEMORY THROUGH PIAGET'S LENS

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Abstract: *Inspired by Piaget's cognitive development theory, the Pop It Numeracy Module introduces an innovative way to improve number concepts and working memory in students with special needs. Education for these learners often lacks strategies suited to their developmental stages, creating significant barriers to building foundational numeracy skills. This study seeks to fill that gap by applying Piagetian principles to a hands-on, interactive learning tool designed for young primary school students with learning disabilities. Using a mixed-methods research approach, the study gathered data through pre-test and post-tests, observations, and teacher interviews to assess the module's impact.The results showed a significant improvement in students' understanding of number concepts and working memory, evidenced by higher test scores and better task performance. Teachers provided positive qualitative feedback, praising the module's ability to engage students and its alignment with their developmental stages, particularly those in Piaget's preoperational and concrete operational phases. These findings suggest that the Pop It Numeracy Module not only addresses cognitive development gaps but also promotes active learning and deeper conceptual understanding. The study concludes that Piaget's cognitive theory provides a strong basis for developing effective numeracy interventions for special needs students. By incorporating tactile, visual, and interactive elements that align with developmental stages, the module shows promise for improving both cognitive and educational outcomes. Further research is encouraged to evaluate its potential for broader application in varied educational settings.*

Keywords: *pop it numeracy module, Piaget's cognitive development theory, numeracy skills development, interactive learning tools, Special Educational Needs (SEN)*

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Introduction

Developing foundational numeracy skills is crucial for the cognitive and academic growth of all learners, particularly those with special needs. Core components such as number concepts and working memory play a vital role in mathematical understanding, enabling students to effectively process, store, and manipulate numerical information (Alloway & Passolunghi, 2011). However, many students with special needs encounter significant challenges in these areas due to cognitive limitations. To address these difficulties, innovative teaching strategies tailored to their unique developmental profiles are essential (Geary, 2013).

Jean Piaget's cognitive development theory provides a valuable framework for understanding how children acquire number concepts. His theory highlights stages of development, particularly the preoperational and concrete operational stages, where active, sensory-based learning is integral to building numerical understanding (Piaget, 1952). Incorporating Piagetian principles into educational practices can help bridge the gap between a student's cognitive abilities and their numeracy development, especially for those needing specialized educational support.

The Pop It Numeracy Module represents an innovative teaching tool grounded in Piaget's principles. By utilizing tactile and interactive materials, this module engages students with learning disabilities and facilitates the mastery of number concepts and working memory. Educators have noted its effectiveness in teaching operations such as addition, subtraction, and multiplication, as its sensory and visual appeal helps sustain students' attention and motivation (Teach Starter, 2021).

Furthermore, incorporating tools like the Pop It into numeracy modules can support the development of working memory, a key cognitive skill for mathematical problem-solving. Research demonstrates that sensory-based interventions, such as using the Pop It, enhance cognitive processing and improve learning outcomes for students with difficulties (Frontiers in Psychology, 2021). This aligns with Piaget's advocacy for active, developmentally appropriate learning experiences.

In conclusion, integrating Piaget's cognitive development theory with innovative tools like the Pop It toy offers an effective approach to enhancing numeracy education for special needs students. By aligning teaching strategies with developmental stages, educators can create meaningful and impactful learning experiences, fostering the acquisition of essential mathematical concepts and addressing persistent gaps in numeracy education (Hekupu, 2024).

Literature Review

Recent research highlights the transformative potential of integrating Jean Piaget's cognitive development theory with modern educational tools to improve numeracy skills and working memory, particularly among children with special needs. Piaget's framework is built upon the idea that children actively construct their understanding of the world through interaction with their environment (Piaget, 1972). His theory has been widely applied in early childhood education, with recent studies highlighting its relevance in designing interactive and constructivist learning environments (Al-Harbi, 2024).

Researcher nowdays explores how Piaget's theory continues to shape educational methodologies. Constructivist classrooms, which emphasize active learning and student-centered instruction, have been implemented in early childhood education with mixed results.

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For example, Muller et al. (2018) examined constructivist approaches in Jewish early childhood classrooms and found that while such methods encouraged deeper engagement, educators faced challenges in balancing open-ended learning with structured instruction. This aligns with Piaget's perspective that children learn best through exploration but require appropriate scaffolding to transition between developmental stages.

Central to this theory are the preoperational (ages 2 to 7) and concrete operational (ages 7 to 11) stages, which play a pivotal role in the development of number concepts. During the preoperational stage, children rely on sensory experiences to connect abstract ideas with tangible actions, while the concrete operational stage enables them to engage in logical reasoning and problem-solving with concrete materials. Research consistently demonstrates that when teaching strategies are aligned with these stages, learning outcomes significantly improve, making Piaget's framework essential in designing interventions for students with learning challenges (Simply Psychology, 2023).

One such innovative tool is the Pop It, which has gained popularity in mathematics instruction for its versatility and alignment with Piagetian principles. The Pop It's tactile and interactive design offers students a sensory, hands-on experience that makes abstract mathematical concepts more accessible. For example, children can use the toy to associate each "pop" with a number, facilitating one-to-one correspondence, a foundational numeracy skill. Beyond basic counting, students can explore addition by "popping" bubbles in groups and subtraction by reversing the process. These interactive and repetitive tasks align with Piaget's emphasis on active learning and schema development, helping children build mental frameworks for understanding mathematical concepts. Studies further highlight that tools like the Pop It sustain students' engagement and deepen their interaction with mathematical content, making learning both enjoyable and effective (Teach Starter, 2021; Teaching Mama, 2023).

In addition to supporting numeracy skills, the integration of Pop It into educational modules addresses another critical area: working memory development. Working memory, which allows children to temporarily hold and manipulate information, is essential for mathematical problem-solving. However, many students with special needs struggle with working memory deficits, making this a key target for intervention. Sensory tools like the Pop It have been shown to enhance cognitive processing by engaging multiple senses simultaneously, which aids in memory retention and task completion. For example, a child solving an addition problem with the Pop It must remember the initial number of bubbles popped, calculate the sum, and verify the result. Such activities foster both cognitive engagement and memory development, particularly for students with learning difficulties (Gathercole & Alloway, 2008; Frontiers in Psychology, 2021).

Modern applications of Piaget's theory extend beyond traditional classroom tools to include educational technology, further enriching learning experiences. The tactile and interactive nature of the Pop It aligns seamlessly with Piaget's stages of cognitive development, providing students with opportunities to explore, experiment, and master foundational concepts. For example, integrating digital versions of the Pop It with features like adaptive feedback or gamified tasks can enhance engagement and personalize learning to meet individual needs. Such innovations ensure that students not only acquire numerical knowledge but also develop higher-order cognitive skills such as problem-solving and pattern recognition (Hekupu, 2024; Early Years TV, 2023).

The application of Piagetian principles in mathematics education has also gained traction. Aziz et al. (2021) explored the development of a Higher Order Thinking Skills (HOTS) Mathematical Problem-Solving Framework using the Bar Model strategy, which is rooted in Piagetian cognitive development. Their study found that incorporating Piaget's theory into mathematical problem-solving frameworks enhanced students' motivation and understanding of mathematical operations, particularly among primary school students. This supports the idea that numeracy learning should align with children's cognitive readiness, reinforcing Piaget's constructivist model.

Further supporting Piaget's framework, computational thinking has emerged as a critical component of modern early education. Saxena et al. (2020) designed a computational thinking (CT) curriculum based on Piaget's theory, integrating unplugged (hands-on) and plugged (digital) activities to cultivate pattern recognition, sequencing, and algorithmic reasoning in young children. Their findings demonstrated that younger students (preoperational stage) struggled with abstract problem-solving, whereas older students (concrete operational stage) exhibited greater success in understanding computational logic. These results align with Piaget's claim that children must first develop concrete reasoning skills before grasping abstract concepts.

The role of physical learning environments in Piagetian education has also been explored. Westberg (2021) analyzed how Swedish preschool designs were influenced by Piaget's theories, emphasizing the importance of providing children with autonomy and interactive learning spaces. Similarly, Ventorini & de Freitas (2020) examined the application of Piaget's and Vygotsky's theories in tactile cartography for blind students, highlighting the necessity of sensory engagement in learning spatial representation. These studies reaffirm Piaget's assertion that children learn best when actively interacting with their environment.

Piaget's influence extends beyond childhood education into higher education learning models. Awaah (2024) introduced the Theory of Higher Education Learning (THEL), an extension of Piaget's cognitive constructivist theory, suggesting that factors such as gender, instructor expertise, and learning opportunities shape students' ability to grasp complex concepts in university settings. Meanwhile, Wang et al. (2024) validated an assessment framework for learning sciences competence among doctoral students, incorporating Piaget's theory to measure knowledge application and problem-solving skills. These findings indicate that Piagetian principles continue to be relevant in higher education, particularly in assessing and developing critical thinking.

In short, the combination of Piagetian principles and innovative tools like the Pop It represents a promising direction for enhancing numeracy skills among students with special needs. By designing teaching methods that align with children's cognitive stages, educators can provide developmentally appropriate and engaging learning experiences that address both numerical understanding and working memory development. This integration not only supports academic growth but also fosters confidence, independence, and a lifelong love of learning in students who face unique educational challenges (Verma, 2024; SAGE Journals, 2022). Future research should continue to explore the scalability of such tools across diverse educational settings while investigating long-term outcomes to ensure sustained impact.

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Piaget's Cognitive Development Theory and the Pop It Numeracy Module

The Pop It Numeracy Module is rooted in Jean Piaget's cognitive development theory, which emphasizes how children construct knowledge through interaction with their environment. The module's design aligns with Piaget's four core concepts: schema, assimilation, accommodation, and equilibrium, facilitating the development of number concepts and working memory in special needs students.

Schema refers to the mental structures or frameworks that individuals use to organize and interpret information. In the context of the Pop It Numeracy Module, schemas are developed through repetitive and tactile interaction with the Pop It toy. For example, a student might initially understand the concept of numbers as a series of "pops" they count on the toy. This tangible representation of numbers helps students build foundational schemas for numerical understanding.

Assimilation occurs when new information is integrated into existing schemas without altering them. Using the Pop It module, students might learn to extend their existing understanding of numbers by associating the "popping" activity with counting. For instance, if a student knows how to count up to five, they may use the Pop It toy to practice counting up to ten by assimilating the new range of numbers into their current schema.

Accommodation involves modifying existing schemas or creating new ones when new information cannot fit into current mental frameworks. In the Pop It module, this might happen when students are introduced to subtraction after learning addition. They must adjust their understanding of numerical operations to include "popping backward" to represent subtraction, thereby accommodating this new concept.

Equilibrium is the process of maintaining cognitive balance between assimilation and accommodation. The Pop It Numeracy Module promotes equilibrium by providing scaffolded activities that gradually increase in complexity. For example, students might first practice simple counting, then progress to addition, and finally tackle subtraction, ensuring that their cognitive frameworks evolve without causing frustration or confusion. The interactive and sensory nature of the module helps students achieve this balance, keeping them engaged and motivated throughout their learning journey.

By incorporating these principles, the Pop It Numeracy Module supports Piaget's view that learning is an active process of constructing knowledge. It offers students hands-on, developmentally appropriate opportunities to explore numerical concepts, reinforcing their cognitive development in line with Piagetian theory.Sustainable tourism as defined by The World Tourism Organization (UNWTO) is tourism that takes full account of current and future economic, social and environmental impacts…

Piaget's Stages of Cognitive Development and the Pop It Numeracy Module

Jean Piaget's theory of cognitive development outlines four primary stages through which children progress: sensorimotor, preoperational, concrete operational, and formal operational. Each stage represents distinct cognitive abilities and ways of interacting with the environment, providing a framework for tailoring educational tools like the Pop It Numeracy Module to students' developmental levels.

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i. Sensorimotor Stage (Birth to 2 Years)

During the sensorimotor stage, children learn through physical interactions and sensory experiences. In this stage, numeracy concepts can be introduced through tactile and visual exploration. For instance, infants and toddlers may interact with the Pop It toy by pressing and hearing the "pop" sound, which helps them develop a sense of cause and effect. Though they are not ready for formal numerical concepts, this activity lays the foundation for future understanding of numbers by encouraging sensory engagement and motor coordination.

ii. Preoperational Stage (2 to 7 Years)

In the preoperational stage, children begin to think symbolically and use language but struggle with logical operations. Numeracy learning in this stage can leverage the Pop It module to help children connect numbers with physical actions. For example, a teacher might use the toy to teach counting by associating each "pop" with a number, reinforcing the concept of one-to-one correspondence. However, children at this stage may find it difficult to reverse operations, such as understanding that subtraction is the opposite of addition, a challenge the module addresses through repetitive, hands-on activities.

iii. Concrete Operational Stage (7 to 11 Years)

Children in the concrete operational stage develop logical thinking about concrete objects and events. This is the optimal stage for the Pop It Numeracy Module to introduce more complex numerical concepts, such as addition, subtraction, and simple multiplication. For example, students can use the toy to visualize addition by "popping" five bubbles on one side and three on the other, then counting the total. Subtraction can be demonstrated by reversing the action, popping a set number and removing some. At this stage, students also begin to understand the conservation of number, recognizing that the quantity remains the same even if the arrangement of the "popped" bubbles changes.

iv. Formal Operational Stage (12 Years and Up)

In the formal operational stage, individuals develop the ability to think abstractly and perform hypothetical reasoning. Although most special needs students may not reach this stage in the same timeframe as their peers, the Pop It Numeracy Module can still be adapted for advanced learners to introduce abstract mathematical concepts. For instance, students might use the toy to explore patterns or sequences, such as creating a visual representation of multiples (e.g., popping every third bubble to represent multiplication by three). This stage emphasizes critical thinking and problem-solving, and the module can be adapted to foster these skills through exploratory tasks and challenges.

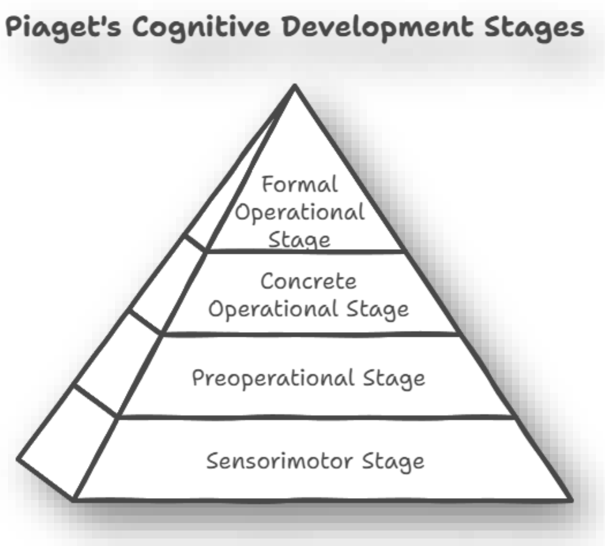

Figure 1: Stages of Piaget's Theory

By aligning activities with Piaget's stages, the Pop It Numeracy Module provides developmentally appropriate learning experiences, enabling students to construct their understanding of number concepts in a tactile and engaging manner. This approach ensures that the module meets students at their current developmental level while guiding them toward more complex cognitive abilities.

Methodology

This study adopts a mixed-methods approach to evaluate the effectiveness of the Pop It Numeracy Module in enhancing number concepts and working memory among Year 1 students with special needs in primary schools. The research integrates quantitative and qualitative methodologies to provide a comprehensive analysis of the module's impact. The quantitative component involves a pre-test and post-test experimental design, while the qualitative component employs focus group discussions with teachers to explore their perceptions and experiences in using the module.

Participants for this study are purposively selected and include Year 1 students identified with learning difficulties in numeracy and teachers from Special Education Integration Programs (PPKI). The quantitative data is collected using standardized assessment tools to measure number concepts and working memory, such as numeracy tests adapted for special education contexts and working memory tasks including digit span and visual-spatial memory assessments. For the qualitative component, semi-structured interviews are conducted with PPKI teachers to gain insights into the module's implementation and alignment with Piaget's cognitive development theory.

The intervention is implemented over an eight-week period, during which the Pop It Numeracy Module is integrated into regular teaching sessions. This module incorporates tactile and interactive tasks that align with Piagetian principles, emphasizing hands-on, sensory-based learning. Students' number concepts and working memory are assessed before (pre-test) and

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after (post-test) the intervention. Concurrently, focus group discussions are held with teachers to evaluate the module's design, effectiveness, and challenges in practical application.

Data analysis involves both quantitative and qualitative techniques. Pre-test and post-test scores are analyzed using paired-sample t-tests to assess changes in students' performance, while correlation analysis examines the relationship between number concepts and working memory. Thematic analysis is applied to qualitative data from focus groups, identifying patterns and themes that provide deeper insights into the module's impact. This mixed-methods approach ensures a holistic evaluation of the *Pop It* Numeracy Module, addressing both measurable outcomes and experiential factors.

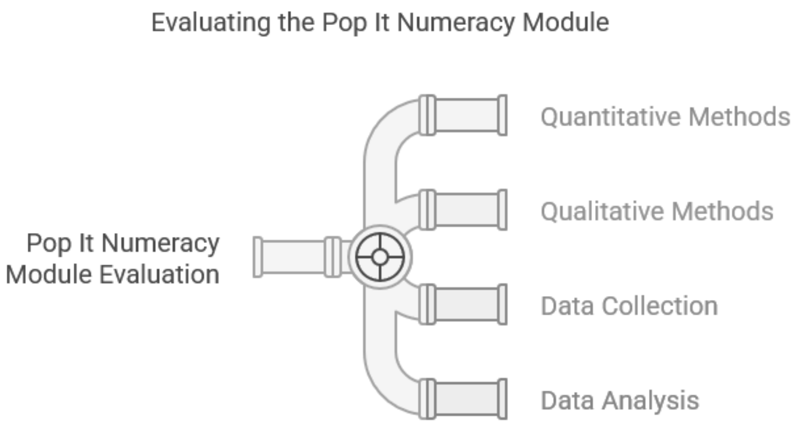

Figure 2: Evaluating in Pop It Numeracy Module

The Impact of Piaget's Theory on the *Pop It* Numeracy Module

Piaget's cognitive development theory significantly influences the design and effectiveness of the Pop It Numeracy Module, particularly in enhancing number concepts and working memory for students with special needs. By aligning teaching strategies with Piaget's principles, the module fosters active learning, hands-on exploration, and developmental appropriateness, which are crucial for building foundational numeracy skills.

One key effect of Piaget's theory is its emphasis on constructivism, where learners actively construct knowledge rather than passively absorbing information. The Pop It Numeracy Module incorporates this principle by providing tactile and interactive activities. For example, students use the Pop It toy to visualize addition by physically "popping" a set number of bubbles, reinforcing the concept of one-to-one correspondence and addition. This hands-on approach encourages learners to engage with the material actively, aiding memory retention and understanding of numerical operations.

Another critical influence of Piaget's theory is the focus on developmental stages. For preoperational learners (ages 2–7), the module simplifies numerical concepts into sensory and visual activities, such as associating each pop with a countable object. For concrete operational learners (ages 7–11), the module introduces logical reasoning through tasks like grouping bubbles to represent multiplication or subtraction. These stage-specific activities ensure the

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tasks align with students' cognitive abilities, reducing frustration and promoting mastery of concepts.

The concept of equilibration from Piaget’s theory also shapes the module’s iterative learning process. Students begin by assimilating new knowledge, such as learning to count using the Pop It toy, and then accommodate more complex ideas, like subtraction, by modifying their existing understanding. This balance between assimilation and accommodation ensures that learning progresses smoothly, building confidence and fostering deeper cognitive processing.

Piaget’s emphasis on schema building directly supports working memory enhancement. As students repeatedly engage with the Pop It module, they develop mental frameworks for number concepts, such as associating the sequence of pops with numerical patterns. This repetitive yet interactive process strengthens their working memory by requiring them to store, manipulate, and retrieve information during tasks. For instance, a student solving a subtraction problem must remember the initial number of popped bubbles, mentally calculate the remaining number, and verify their result by counting again.

Through its alignment with Piaget’s theory, the Pop It Numeracy Module transforms abstract mathematical concepts into concrete, engaging experiences. This approach not only enhances number concepts and working memory but also provides students with the tools to advance their cognitive development at their own pace, ensuring meaningful and lasting learning outcomes.

Conclusion

The integration of Piaget’s cognitive development theory with the Pop It Numeracy Module has demonstrated significant potential in enhancing number concepts and working memory for students with special needs. By aligning the module’s design with Piagetian principles such as schema development, assimilation, accommodation, and equilibration, the Pop It Numeracy Module provides a hands-on, developmentally appropriate learning tool that facilitates active engagement and cognitive growth. The module’s tactile nature, coupled with its alignment to various cognitive stages, allows students to actively construct their understanding of numeracy concepts, thereby enhancing both their mathematical abilities and working memory.

Looking ahead, there is hope that the Pop It Numeracy Module will continue to evolve as a valuable tool for inclusive education, catering to diverse learning needs. Future iterations of the module could incorporate adaptive technology to further personalize learning experiences, such as interactive digital Pop It versions or integration with augmented reality (AR) to provide immersive, real-time feedback. Moreover, expanding the module to cover a wider range of numeracy skills, such as fractions, geometry, or word problems, could provide a more comprehensive learning experience for students.

Additionally, future research should explore the long-term effectiveness of the Pop It Numeracy Module by tracking the progress of students over extended periods and across various educational settings. This could involve conducting large-scale trials to assess its impact on different age groups, educational systems, and various learning disabilities. Furthermore, collaboration with teachers, parents, and education specialists will be crucial in refining the module to ensure it remains adaptable to the evolving needs of special education students.

Ultimately, the Pop It Numeracy Module has the potential to transform numeracy education for students with special needs, making learning more accessible, enjoyable, and effective. By continuing to innovate and adapt the module to the needs of diverse learners, educators can harness its full potential in supporting the academic success of students with learning challenges. In conclusion, Piaget's cognitive development theory remains a foundational model in educational psychology, influencing both early childhood learning environments and advanced educational frameworks**.** Studies continue to validate his principles in constructivist teaching methods, mathematics instruction, computational thinking, and even higher education assessment models. As education evolves, integrating Piagetian insights with modern technological and pedagogical advancements will be crucial in fostering meaningful and developmentally appropriate learning experiences.

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