INOSR Experimental Sciences 13(3):1-7, 2024. ISSN: 2705-1692
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International Network Organization for Scientific Research
https://doi.org/10.59298/INOSRES/2024/13317.000

How the Brain Processes Numbers: What This Means for Math Education in West Africa

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ABSTRACT

Teaching mathematics in West Africa is critical because of the collision of culture and brain function there. Numerical notions are significantly influenced by West African educational institutions, language diversity, and cultural aspects. Motivation and retention of mathematical concepts may be increased in pupils by Native American knowledge, language resources, and community-based activities. Maths instruction may involve the brain more fully with the use of technology-based techniques and neurodevelopmental research. Both mobile learning applications and digital learning platforms may provide engaging and conveniently available learning opportunities. Information that young people in West Africa get also heavily depends on the actions and engagement of their parents at home. Finding out how different languages spoken in the area, traditional number systems, and teaching approaches impact people's capacity to understand numbers is the aim of this research. It addresses how, with parental involvement and at home activities, kids may learn mathematics and grow their brains. Furthermore, discussed is the need of cultural relevance in mathematical teaching. Understanding the effect of mental activities on the brain and gaining understanding about neurodevelopment help us to enhance customised learning. We utilised relevant published data (2004–2014) from diverse, reliable databases. The findings imply that to raise children's interest in mathematics, teacher preparation programmes and technology-based methods should be used. Children in West Africa would therefore at last have more equal educational chances and improved neurodevelopmental results.

Keywords: brain, numbers, mathematics, education, neurodevelopment, West Africa

INTRODUCTION

Teaching strategies that work in West Africa need understanding of the relationship between mathematical brain functions and cultural factors. Language diversity, historical numeration systems, and pedagogy all affect numerical comprehension [1]. The interest in and capacity to understand mathematical content of pupils can be increased by using historically and culturally appropriate teaching techniques. Arithmetic activities done at home with parental participation can help kids learn and grow neurologically. Technologically advanced methods and teacher preparation programmes can increase kids' brain involvement in mathematics education, and neurodevelopmental researchers can help build culturally relevant teaching practices [2]. Disparities in the success of mathematical instruction may be eliminated in part by this. Future academic achievement of a kid can be enhanced by home-based maths exercises and strong parental involvement [3].

There are cultural influences on the neural processing of arithmetic

People's perceptions of, thoughts about, and interactions with numerical ideas are significantly influenced by cultural factors. In West Africa, a region well-known for its diverse language, customary numeration systems, and unique educational practices, these cultural elements

interact to influence the neural mechanisms underlying number cognition [4]. Understanding how cultural factors impact the development of arithmetic skills may be fairly enlightening for instructors attempting to enhance arithmetic teaching in West African environments. Variability in language affects numerical processing by influencing the representation, communication, and internalisation of numerical concepts [5]. Language patterns for expressing quantities may vary among languages, as may numerical systems and counting traditions. Studies indicate that speakers of languages with transparent number systems may be more numerate than speakers of languages with opaque numerical systems [6]. Moreover, bilingualism and multilingualism—both widespread in many West African communities—can influence number processing by promoting cognitive flexibility and cross-linguistic transfer of numerical skills.

Rooted in historical and cultural practices, traditional numeration systems affect how individuals interpret and use numerical values. In West Africa, there are several indigenous numerical systems coexisting with modern Arabic or European number systems [7]. These systems include, many times, these old counting methods, symbolic representations, and cultural meanings associated with numbers [8]. Conventional numeration systems result in spatial, visual, and kinesthetic representations of numerical values that can influence information absorption and problem-solving abilities in arithmetic.

Teaching and studying mathematics are influenced by historical legacies, cultural values, and society mores found in West Africa. diverse cultural settings result in diverse classroom dynamics, teaching methods, and learning resources, all of which impact how involved students are with arithmetic subject and how their brains respond to mathematical stimuli [9]. Certain West African societies pass on mathematical skills and information orally and via narrative.

Mathematical content can be better understood, remembered, and motivated by teachers who include cultural significance into their instruction [10]. Teachers could, for example, teach numerical concepts in regional languages, combine folklore or traditional games with mathematical themes, and include students in real-world problem-solving activities that reflect their cultural experiences.

More understanding of the ways in which socioeconomic and cultural factors influence cognitive development as well as significant insights into the brain mechanisms underlying numerical cognition are provided by neurodevelopmental research in West African populations [11]. This study made clearer how biology, culture, and environment interact to form numerical abilities by looking at brain structure, function, and connectivity in individuals from various backgrounds. The way that cultural factors impact the way the brain processes mathematics is complicatedly shown via brain connection. diverse brain networks supporting numerical cognition have been identified by functional connectivity analyses utilising diffusion tensor imaging (DTI) or resting-state fMRI in diverse cultural and socioeconomic contexts. For students in West Africa, equitable learning opportunities and positive neurodevelopmental outcomes depend on resolving socioeconomic disparities in access to resources and high-quality education. All children can succeed in math and beyond if instructors implement inclusive practices and approaches that support academic achievement and cognitive development [12].

West Africa: Language and Numerical Processing

The ability to speak multiple language variety, and cultural customs all have an impact on the complex and dynamic field of research that is the connection between language and number processing in West African settings [12]. It takes knowledge of how several languages encode numerical concepts and how they are used in arithmetic training to create efficient teaching methods that accommodate the wide range of linguistic backgrounds of the pupils in thearea.

In West Africa, multilingualism is a widespread phenomena where people are frequently fluent in several languages, including lingua franca, colonial, and indigenous languages [13]. Since language shapes cognitive processes associated to mathematics, the relationship between language competence and numerical processing is intricate. Studies indicate that a person's language(s) of speech might affect their methods for counting, representing numbers, and solving problems. The ways that different languages represent numerical ideas, including counting systems and numerical words, varies. The setting in which multilingual people use their linguistic resources may cause differences in their numerical performance between languages.

The way that different languages encode number ideas reflects the historical and cultural impacts on numerical cognition [14]. Rich number systems involving tallying, grouping, and spatial metaphors for counting are often found in indigenous languages of West Africa. Inherent from European traditions,

decimal-based counting systems used in colonial languages may not be culturally relevant or compatible with learners' natural grasp of numbers. Students may find it difficult to move from native languages to colonial languages in formal education settings, especially when learning abstract mathematical ideas. In West African classrooms, teachers can use language-specific techniques to enhance numerical cognition and arithmetic learning outcomes by integrating aspects of indigenous languages, cultural practices, and contextualised examples into instruction. By doing so, students' language and cultural backgrounds may be reflected in meaningful learning experiences that help to close the gap between abstract ideas and real-world experiences [15].

Neural Correlates of Traditional Arithmetic Practices:

Among the centuries-old methods of problem-solving and mathematical reasoning represented in traditional arithmetic and numeration systems particular to West Africa are counting boards, mnemonics, and oral calculating approaches. Examining the neural correlates of these traditional activities clarifies how the brain processes arithmetic knowledge in culturally specific contexts, which has significant implications for teaching methods that include cultural heritage into arithmetic learning.

Known by several names including "Soroban" or "Lubaale," counting boards are ancient mathematical tools utilised in West African cultures for calculations. Beads or pebbles arranged in rows and columns on these boards let users change number values by touch and sight. Counting boards are said to train several brain regions related to spatial processing, motor control, and working memory. Experiments with neuroimaging have shown that moving actual objects on counting boards activates parietal brain regions associated with spatial attention and arithmetic computation [16].

Moreover, the way the beads are arranged on the board may facilitate the brain's encoding of numerical information, therefore enhancing memory and recall of arithmetic facts. West African cultures use mental arithmetic via chants, rhythmic patterns, and spoken methods; they mostly depend on mnemonic devices and oral calculating methods. Many times, these techniques involve employing mnemonics or memory aids particular to a culture to assist with arithmetic processing and problem-solving. According to studies, mnemonic devices use language processing systems to enhance arithmetic skills by drawing on cognitive resources associated to language and memory [17]. The construction of teaching methods that use cultural legacy in arithmetic education is made possible by the brain correlates of traditional arithmetic procedures in West Africa. Teachers can adapt their instruction to incorporate culturally appropriate strategies and promote students' deeper learning and participation by understanding how these activities use different brain regions than Western arithmetic techniques.

Technology-Based and Teacher Training Approaches to Enhance Neural Engagement in Arithmetic

Technology-based solutions show significant potential for improving brain engagement in mathematics instruction in West Africa, where traditional teaching methods are common and educational resources may be few. Students may overcome learning barriers, have more access to excellent education, and develop their basic numeracy skills by using technology. Here, we look at technology-based approaches tailored to the West African context and strategies for teacher training to make their successful implementation easier [18].

Mobile Learning Applications: Mathematical concept practice on smartphones or tablets is made possible by easily accessible and interesting mobile learning apps created for arithmetic education. Many times, these software feature interactive games, tests, and tutorials designed to satisfy the educational requirements of countries in West Africa. Through their quick feedback, incentives, and customised learning experiences, these apps promote brain activity. Students' motivation, attention span, and knowledge retention all rise when they actively participate in the learning process. Mobile learning applications can be included into lesson plans, given as homework assignments, or used in classroom activities by teachers to promote their use. Educators may show effective integration of the applications into classroom environments and become acquainted with them through training sessions.

Digital Learning Platforms: Educational tools abound in West African nations and include practice exercises, interactive tutorials, and instructional films. By offering multimedia material like animations, simulations, and visualisations, these platforms accommodate a range of learning styles and improve the educational process. Students that use these resources learn abstract mathematical ideas, use several senses, and become more adept in arithmetic thinking [19]. Digital learning platforms allow teachers to improve classroom instruction, provide challenging students extra support, or customise learning opportunities to meet specific requirements. Courses for professional development

give teachers instruction in using digital tools, choosing appropriate curricula, and navigating digital platforms. All things considered, these platforms provide a complete and customised educational experience.

Interactive Whiteboards and Multimedia Presentations: Animated, video, and demonstration-based interactive whiteboards let teachers provide dynamic and interesting math lessons. Students are drawn to these displays, which also help them understand concepts better. Using a range of sensory modalities, interactive whiteboards promote spatial thinking, cognitive flexibility, and sensorimotor integration, therefore enhancing information processing and brain activity. Teacher preparation seminars can concentrate mostly on the use of these technologies, which will enable teachers to develop the abilities needed to design engaging courses, include multimedia materials, and promote student cooperation and involvement in the classroom [20]. This strategy can improve maths education.

Teacher Training Approaches to Support Technology Integration

In addition to technology-based approaches, comprehensive teacher training is essential to support the effective integration of educational technology into arithmetic instruction in West Africa. Here are a few key teacher training approaches tailored to the context of West Africa:

Workshops on Capacity Building: We propose capacity-building workshops to expose teachers to technology-based approaches and teach them how to use digital tools and resources efficiently. These sessions ought to concentrate on useful techniques for integrating technology into mathematics education, including lesson planning, resource selection, and evaluation techniques. The training's objective is to impart practical classroom technology usage techniques that emphasise formative evaluation, active engagement, and student-centered learning [21]. Additionally covered in the course will be how to use technology to support students' growth in math class conceptual understanding, problem-solving abilities, and critical thinking.

Supportive Learning Communities: The book promotes the establishment of learning communities where teachers may work together, talk about efficient techniques, and exchange ideas on using technology in mathematics education. It also promotes a peer-mentoring and cooperative culture to investigate novel technological uses and get over obstacles.

Access to Technical Support and Resources: In order to enable teachers utilise technology in the classroom effectively and autonomously, it is advised that they have access to technical support and resources such user manuals, online tutorials, and training materials. West African teachers can combine targeted teacher training strategies with technology-based approaches to create dynamic and inclusive learning environments [22]. These environments are designed by teachers to optimise neural activity, improve conceptual understanding, and help pupils succeed in arithmetic training. By working together and pursuing ongoing professional development, educators can fully utilise the revolutionary potential of educational technology to improve students' numeracy skills and provide the best possible learning outcomes for all local children.

Parental Involvement and Home-Based Arithmetic Activities

In West Africa, children's brain processing of number concepts is greatly shaped by their parents' involvement and home-based arithmetic activities [23]. In certain places, where formal schooling may be rare, learning and cognitive growth largely occur inside the family. By practicing culturally appropriate math tasks at home, parents may promote brain development, mathematical learning in their children, and academic performance. We'll talk about the necessity of parental involvement and examine a few home-based maths activities inspired by West African culture.

Parental Involvement: West Africa lacks the educational resources needed, hence parents must be involved to support their children's education and promote cognitive growth [24]. Early educators and role models, parents influence the attitudes and actions of their children towards mathematics. At home arithmetic exercises show how important mathematics is in daily life, foster a good attitude towards learning, and empower kids to boldly investigate mathematical ideas.

Culturally Relevant Arithmetic Activities: Using strategic planning, counting, and spatial thinking, traditional African games like Ludo, Mancala, and Ayo may be introduced to children by their parents to promote mathematical thought. These games get the brain working and improve mathematical fluency. Including mathematical ideas into storytelling sessions may increase the fun and cultural relevance of learning. In order to help their children see mathematical concepts in practical settings, parents might narrate stories with numerical themes, measures, or patterns [25]. Allowing kids to engage in routine math-related tasks like cooking, budgeting, or shopping also offers them opportunity for practical learning and reinforces mathematical concepts in real-world

contexts. Children's problem-solving and numerical ability can be developed in this way.

Enriching the Home Learning Environment: At home, a dynamic learning environment promotes inquiry, interest, and discovery. To help their kids' cognitive and numeracy abilities, parents might set up a study area with instructional supplies. Children that have a maths practice programme develop their academic habits and self-regulation abilities [26]. Parents and kids may create a cooperative and open learning atmosphere where kids feel at ease asking questions, getting help, and sharing their mathematical discoveries.

Promoting Neural Development: Home math exercises work the parts of the brain involved in problem-solving, spatial reasoning, and numerical processing. Activities involving hands-on learning include arranging shapes, counting beads, and solving puzzles. Stories, games, and practical applications of culturally appropriate mathematics engage many sensory modalities, which improves information processing and brain activity [27]. These exercises improve brain connections in mathematical cognition and encourage sensorimotor integration.

Supporting Parents in Arithmetic Education: Parents should be given the resources and direction they need to enable at-home maths education [28]. This is possible with lectures, workshops, and community outreach initiatives. Through resource sharing, best practices discussion, and parental involvement in teaching children maths, cooperation between educational institutions and community groups may further improve the effect of home-based learning initiatives.

CONCLUSION

Good knowledge of how the brain processes numerical information is necessary to develop efficient teaching strategies in West Africa. All around the region, numerical cognition is shaped by cultural factors, language variety, conventional numeration systems, and educational practices. Employing indigenous knowledge, linguistic resources, and community-based approaches, teachers can improve students' motivation, comprehension, and recall of mathematical concepts. Scientific study of neurodevelopment sheds light on the interactions between biology, culture, and environment as well as the neural processes supporting numerical cognition. Through the application of neuroscience research to educational practice, teachers may create customised teaching plans that optimise brain activity and advance equitable learning possibilities. Learning obstacles may be surmounted and neural participation in mathematics instruction increased by using technology-based methods. Digital platforms, interactive whiteboards, and mobile learning applications are few instances of such strategies. Educational technology may be effectively included into the classroom by teacher preparation programmes, resulting in dynamic and friendly learning environments for every student. Both children's mathematics learning and brain development can be aided by parental involvement and at-home arithmetic exercises. Teachers who understand and use the cultural background of West Africa, including research on neurodevelopment, and who adopt technologically based methods can help children succeed in arithmetic education and promote healthy neurodevelopmental outcomes.

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CITE AS: Echegu Darlington Arinze (2024). How the Brain Processes Numbers: What This Means for Math Education in West Africa. INOSR Experimental Sciences 13(3):1-7. https://doi.org/10.59298/INOSRES/2024/13317.000