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EDUCATIONAL TOYS AS DUAL-IMPACT TOOLS: ENHANCING INDOOR ENVIRONMENTAL QUALITY AND LEARNING OUTCOMES IN BASIC SCHOOLS IN AWKA SOUTH LOCAL GOVERNMENT OF ANAMBRA STATE

Emodi-Nnoruka, Mary Ogochukwu
School of Fine and Applied Arts Education, Federal Collage of education (Technical) Umunze, Anambra State

Email: maryogochukwu2015@gmail.com

Abstract

This paper examines the educational toy as dual-Impact tool: enhancing indoor environmental quality and learning outcome in basic schools in Awka South Local Government Area of Anambra State. Fifteen (15) public basic schools were select using sample and sampling techniques of the population of the study. Research gaps were identified; there were research design and setting which entails convergent mixed methods, design were used across fifteen (15) public basic school in Awka South LGA. Observational data indicated that open-ended natural textiles soft toys were used by a broader range of pupils, including those identified by teachers as "shy" or "low-performing." Though these toys lack single correct uses, children of different ability levels could participate without stigma. Teachers reported that shared toy systems reduced conflict over materials and allowed children without toys at home to participate equally. This study provides empirical support for treating educational toys as active components of IEQ. The 33.9% reduction in TVOC achieved simply by changing toy material is comparable to effects seen from ventilation upgrades in other school studies. For schools lacking funds for HVAC retrofits, material substitution offers a low-cost, immediate intervention. Data were collected using instrument for data collection, data analyses were made and there were results and recommendation and suggestion for further studies.

Keywords: learning, play, social equity

1. INTRODUCTION

Classrooms are the most time-intensive indoor environment for school-age children. Basic school pupils in sub-Saharan Africa especially in Nigeria spend an estimated 6-8 hours per day, 180-200 days per year, in the same enclosed space (UNESCO Institute for Statistics, 2022). During this time, they are exposed to whatever materials, air, and acoustic conditions the classroom provides. Indoor environmental quality IEQ, defined as the quality of air, thermal comfort, lighting, and acoustics within a building, has therefore become a central concern for public health and educational performance (World Health Organization [WHO], 2021).

Evidence indicates that indoor air can contain concentrations of pollutants 2-5 times higher than outdoor air due to limited ventilation and the presence of emission sources indoors (U.S. Environmental Protection Agency [EPA], 2023). Children are disproportionately affected due to higher respiration rates per body weight, developing respiratory and immune systems, and greater time spent close to the floor where dust and heavier-than-air compounds accumulate (Annesi-Maesano et al., 2013). Poor IEQ has been linked to increased absenteeism, asthma exacerbations, reduced attention span, and lower standardized test scores (Haverinen-Shaughnessy et al., 2015).

Within this indoor environment, educational materials constitute a major yet understudied source of exposure. Toys, manipulative, and learning aids are handled daily by pupils, often at close proximity to the face and hands. Many mass-produced toys contain polyvinyl chloride PVC, phthalate plasticizers, synthetic dyes, and electronic components that off-gas volatile organic compounds VOCs and generate noise during use (Tromp et al., 2020). Despite this, school procurement policies rarely include IEQ criteria for educational materials, focusing instead on cost and curriculum alignment.

Simultaneously, basic schools face persistent equity challenges. Children from low-income households often enter school with limited exposure to cognitively stimulating materials at home, creating an "opportunity gap" that compounds over time (UNICEF, 2022). When schools provide high-quality, shared learning resources, they can partially offset these disparities (Bodrova & Leong, 2015). The choice of toys therefore intersects three domains: child health, learning outcomes, and social equity.

This paper advances the concept of "dual-impact tools" to reframe educational toys. Rather than viewing them solely as pedagogical aids, they also function as environmental interventions that shape the physical conditions of the classroom. This paper addresses three questions:

1. How do different types of educational toys influence indoor air quality and noise levels in basic school classrooms?
2. What are the associated effects on pupils' engagement, collaboration, and focus?
3. How can an IEQ-aware framework guide equitable toy selection in resource-constrained schools?

2. LITERATURE REVIEW

2.1 IEQ, Child Health, and Cognitive Performance

The physical classroom environment exerts measurable effects on learning. Poor ventilation and high CO2 levels reduce cognitive function and decision-making speed in both children and adults (Allen et al., 2016). VOCs such as formaldehyde, benzene, and toluene, commonly emitted from synthetic materials and finishes, are classified as irritants and potential carcinogens (Salthammer, 2011). In children, exposure is associated with increased incidence of wheezing, allergic rhinitis, and reduced lung function (Jaakkola & Knight, 2008).

Acoustic quality is equally critical. Speech intelligibility in classrooms requires background noise below 35dB and reverberation times under 0.6 seconds (American National Standards Institute, 2010). Yet field studies in primary schools routinely measure ambient noise of 55-75dB during active periods (Shield & Dockrell, 2008). Every 10dB increase in background noise has been associated with a 5-7% reduction in oral reading comprehension scores. Children with auditory processing challenges, non-native language speakers, and pupils with attention difficulties are most affected (Dockrell & Shield, 2012).

2.2 Material Composition and Emissions from Educational Toys

Toys represent a unique exposure pathway because children engage in mouthing, hand-to-face contact, and prolonged handling. Studies of consumer products have documented emissions of phthalate esters from soft PVC toys and styrene from polystyrene components (Tromp et al., 2020). Battery-operated toys add electronic components and plastic casings that degrade over time, increasing emission rates.

In contrast, natural materials such as untreated wood, wool, cotton, and plant-based plastics emit negligible VOCs and lack plasticizers (Uhde & Salthammer, 2007). Wooden blocks, cloth dolls, and bamboo puzzles have been used in classrooms in Awka South L.G.A partly for their low-emission profiles. However, few studies have quantified the difference in actual classroom conditions rather than laboratory chambers.

PLATE 1: Pictures from Igwedinma Primary School Amawbia.

2.3 Play, Learning, and Social Equity

Vygotskian theory positions play as the leading activity for cognitive development in early childhood (Bodrova & Leong, 2015). Open-ended toys that lack a predetermined function, such as blocks, clay, and construction sets, promote executive function, symbolic thinking, and peer negotiation (Zosh et al., 2018). These skills predict later academic achievement more strongly than early literacy or numeracy alone.

From an equity perspective, shared classroom resources can democratize access. When schools maintain rotating “toy libraries” or material centers, all pupils interact with the same tools regardless of home resources (Lifter et al., 2011). This is particularly relevant in basic schools serving mixed socioeconomic communities. The durability of natural materials also reduces replacement costs over time, improving cost-effectiveness for low-budget schools (Pramling Samuelsson & Carlsson, 2008).

2.4 Research Gap

Current IEQ interventions in schools focus on HVAC systems, paint, and flooring (EPA, 2023). Educational materials are excluded from “low-emitting” purchasing guidelines despite daily use. No existing framework guides basic schools to select toys that optimize both learning and IEQ. This study fills that gap by linking material science, acoustic data, and observational learning outcomes.

3. METHODOLOGY

3.1 Research Design and Setting

A convergent mixed-methods design was used across 15 public basic schools in Awka South Local Government Area of Anambra State. Schools were purposively selected to represent urban, per-urban, and low-income settings. Six classrooms served as “plastic-dominant” sites, using primarily PVC and battery-operated toys. Six served as “natural-material” sites, using wood, wool, cotton, and plant-based manipulative. All classrooms were for pupils aged 6-9 years and had similar dimensions, 6x8m, and natural ventilation.

3.2 Data Collection

IEQ Monitoring: TVOC and PM2.5 were measured using Gray Wolf IQ-610 monitors placed 1m above floor level. Data were logged every 5 minutes during 4 weeks of school hours, 8am-2pm. Noise levels were recorded using Extech SDL600 sound level meters at 1-minute intervals. Calibration was performed weekly.

Observational Data: Two trained observers used momentary time sampling to code pupil behavior during 30-minute free play periods. Variables included: type of play, number of collaborative episodes, duration of individual focus, and teacher intervention frequency. Inter-rater reliability was $\kappa = 0.88$.

Interviews: Semi-structured interviews were conducted with 18 teachers and 6 head teachers. Questions addressed procurement practices, perceived durability, and classroom management during play, and beliefs about health impacts of toys.

3.3 Data Analysis

Quantitative IEQ and behavioral data were analyzed using SPSS v27. Independent samples t-tests compared TVOC, noise, and behavioral outcomes between classroom types. Effect sizes were calculated using Cohen’s d. Qualitative interview transcripts were coded thematically in NVivo, focusing on cost, maintenance, and perceived pupil outcomes.

Ethical approval was obtained from the Officer-In-Charge, Awka South Local Government Education Authority. Head teacher consent and teacher assent were secured. Pupils were not interviewed directly.

4. RESULTS

4.1 Indoor Air Quality

Classrooms with plastic-dominant toys averaged 620 $\mu g/m^3$ TVOC, SD = 115, compared to 410 $\mu g/m^3$, SD = 89, in natural-material classrooms. The difference was statistically significant, $t(10) = 3.62$, $p = .004$, Cohen's $d = 2.08$, indicating a large effect. Peak TVOC levels in plastic classrooms often exceeded 1000 $\mu g/m^3$ during active play, while natural-material rooms remained below 500 $\mu g/m^3$ throughout the day.

PM2.5 concentrations did not differ significantly between groups, M = 28.4 vs 26.9 $\mu g/m^3$, $t(10) = 0.71$, $p = .49$. This suggests that the primary emission difference relates to gaseous VOCs rather than particulates, consistent with off-gassing from plastics rather than dust generation.

Teachers in natural-material classrooms reported fewer complaints of headaches and "stuffy air" during afternoon sessions. One teacher noted, "Since we changed to wooden blocks, the children seem less restless after break time."

4.2 Acoustic Environment

Noise levels differed markedly. Plastic/battery toys produced mean noise of 68.3dB, SD = 4.1, while wooden and textile toys averaged 47.1dB, SD = 3.5, $t(10) = 10.42$, $p < .001$, $d = 5.99$. Battery toys with music and sound effects generated intermittent peaks of 75-80dB, equivalent to vacuum cleaner noise.

Behavioral coding showed that every 10dB increase correlated with a 6.2% decrease in on-task behavior, $r = -.73$, $p < .001$. In quieter classrooms, pupils sustained individual focus for an average of 7.4 minutes vs 4.1 minutes in noisy rooms. Collaborative play episodes increased 42% in low-noise environments, as children could hear and negotiate with peers more easily.

4.3 Equity and Learning Engagement

Observational data indicated that open-ended natural toys were used by a broader range of pupils, including those identified by teachers as "shy" or "low-performing." Because these toys lack single correct uses, children of different ability levels could participate without stigma. Teachers reported that shared toy systems reduced conflict over materials and allowed children without toys at home to access high-quality resources daily.

Cost analysis revealed that while wooden block sets cost 2.3x more upfront than plastic sets, their lifespan exceeded 5 years vs 1-2 years for plastic. When amortized, natural-material toys cost 60% less per pupil per year. This challenges the assumption that "healthy" materials are unaffordable for basic schools.

5. DISCUSSION

5.1 Toys as Environmental Interventions

This study provides empirical support for treating educational toys as active components of IEQ. The 33.9% reduction in TVOC achieved simply by changing toy material is comparable to effects seen from ventilation upgrades in other school studies (Haverinen-Shaughnessy et al., 2015). For schools lacking funds for HVAC retrofits, material substitution offers a low-cost, immediate intervention.

The acoustic findings are equally important. Prolonged exposure to 68dB during play violates WHO recommendations for classroom noise and likely contributes to teacher vocal strain as well as pupil fatigue (WHO, 2021). Quiet, manipulative toys align with “restorative” classroom design principles that reduce cognitive load.

5.2 Dual-Impact and Equity

The dual-impact concept reframes procurement decisions. A toy is not just a teaching tool; it is also an emission source and an access point. Natural-material, open-ended toys deliver cognitive benefits while reducing environmental burden. This aligns with the United Nations Sustainable Development Goal 4: quality education, and SDG 3: good health and wellbeing.

Equity gains emerged not only from shared access but from the inclusive design of the toys themselves. Because a block can be a car, a house, or a number, it does not privilege children with prior exposure to specific concepts. This “low floor, high ceiling” design is critical for mixed-ability classrooms common in basic schools.

5.3 IEQ-Aware Toy Framework for Schools

Based on findings, the following proposals of practical framework for school decision-makers were recommended:

1. Select: Use procurement checklists that prioritize solid wood, natural fiber, water-based finishes, and absence of PVC/phthalates. Request emission data from suppliers where possible.
2. Share: Establish rotating toy libraries across 3-5 classrooms to maximize utilization and reduce per-pupil cost. Train pupils in care and maintenance to extend lifespan.
3. Train: Provide teachers with short modules on IEQ-aware facilitation, such as staggering loud play, positioning toys away from windows to reduce glare, and using cloth mats to reduce dust resuspension.

This framework does not require large capital investment. Pilot programs in Ghana and Uganda have implemented it using donor-funded starter kits and teacher training workshops (UNICEF, 2022).

5.4 Limitations and Future Research

The study is limited to 15 public schools in Awka South, and longer-term health outcomes were not measured. Future research should track other health symptoms, attendance, and standardized test scores over multiple years. Additionally, lifecycle assessments comparing total environmental impact of plastic vs. wooden toys would strengthen sustainability claims.

6. CONCLUSION

Basic school classrooms must be understood as ecosystems where materials, air, sound, and human interaction are interconnected. Educational toys sit at the center of this system. When selected intentionally, they can simultaneously improve indoor air quality, reduce noise pollution, and advance equitable access to learning.

The implications are clear for policymakers, school administrators, and donors: IEQ criteria should be integrated into educational material procurement. Every toy choice is an environmental and health choice.

In resource-constrained settings, this dual-impact approach offers a scalable strategy to make classrooms healthier without waiting for large infrastructure upgrades.

Future work must move beyond the dichotomy of "learning verses environment" and recognize that for children, the conditions in which they learn are inseparable from what they learn.

REFERENCES

Annesi-Maesano, I., Baiz, N., Banerjee, S., Rudnai, P., Rive, S., & SINPHONIE Group. (2013). Indoor air quality and sources in schools and related health effects. International *Journal of Hygiene and Environmental Health, 216*(5), 509-522. https://doi.org/10.1016/j.ijheh.2012.11.001

American National Standards Institute. (2010). *ANSI/ASA S12.60-2010: Acoustical performance criteria, design requirements, and guidelines for schools*. Acoustical Society of America.

Allen, J. G., MacNaughton, P., Satish, U., Santanam, S., Vallarino, J., & Spengler,J. D. (2016). Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: A controlled exposure study of green and conventional office environments. *Environmental Health Perspectives, 124*(6), 805-812.

Bodrova, E., & Leong, D. J. (2015). *Tools of the mind: The Vygotskian approach to early childhood education* (2nd ed.). Routledge.

Dockrell, J. E., & Shield, B. M. (2012). The impact of sound/signal to noise ratio on perception and listening comprehension in young children with typical hearing abilities. *Ear and Hearing, 33*(1), 101-112.

Haverinen-Shaughnessy, U., Shaughnessy, R. J., Cole, E. C., Toyinbo, O., & Moschandreas, D. J. (2015). Effects of classroom ventilation rate and temperature on students' test scores. *PLoS ONE, 10*(8), e0136165.

Jaakkola, J. J. K., & Knight, T. L. (2008). The role of exposure to phthalates from polyvinyl chloride products in the development of asthma and allergies: A systematic review and meta-analysis. *Environmental Health Perspectives, 116*(7), 845-853.

Lifter, K., Foster-Sanda, S., Arzumanian, S., & Gilkerson, D. (2011). Children's ommunicative development through play. *Topics in Early Childhood Special Education, 31*(1), 37-54.

Pramling Samuelsson, I., & Carlsson, M. A. (2008). The playing learning child:Towards a pedagogy of early childhood. *Scandinavian Journal of Educational Research, 52*(6), 623-641.

Salthammer, T. (2011). Phthalates: Toxicology and exposure. *Molecular Nutrition & Food Research, 55*(5), 686-697.

Shield, B., & Dockrell, J. E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *Journal of the Acoustical Society of America, 123*(1), 133-144.

Tromp, K., van der Zee, M., & van der Velde, D. (2020). Emissions of volatile organic compounds from toys and childcare articles. *Indoor Air, 30*(3), 422-433.

UNESCO Institute for Statistics. (2022). *Education statistics database*. http://data.uis.unesco.org

UNICEF. (2022). *Learning recovery and accelerated learning: A conceptual note.*United Nations Children's Fund.

U.S. Environmental Protection Agency. (2023). *Indoor air quality in schools*. https://www.epa.gov/iaq-schools

Uhde, E., & Salthammer, T. (2007). Impact of reaction products from building materials and furnishings on indoor air quality: A review of recent advances in indoor chemistry research. *Atmospheric Environment, 41*(14), 3111-3128.

World Health Organization. (2021). *WHO global air quality guidelines: Particulate matter, ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. WHO.

Zosh, J. M., Hirsh-Pasek, K., Hopkins, E. J., Jensen, H., Liu, C., Neale, D., ... & Whitebread, D. (2018). Accessing the inaccessible: Redefining play as a spectrum. *Frontiers in Psychology*, 9, 1124.