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Research Article

Noodle: An Innovative, Affordable Virtual Learning Device For Inclusive Education

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ABSTRACT

During the gradual transition of the teaching-learning process, reliance on virtual learning has become unavoidable in the post-pandemic period. Virtual learning has proven essential for the sustainability of education during the challenging pandemic phase. Despite the uncertainty surrounding the complete return to traditional in-person learning due to the significant impact of virtual learning, a hybrid model is anticipated to be the future of education. However, every innovation comes with its own set of advantages and disadvantages. For virtual learning, which requires pervasive and ubiquitous devices such as mobile phones, personal computers, laptops, notebooks, tablets, iPads, iPods, etc., affordability becomes a critical issue, leading to a digital divide among underprivileged children. Additionally, addressing the knowledge transfer to these underprivileged children involves considering their nutritional needs and mental health. The solution proposed is a low-cost device named NOODLE, which stands for New Normal Object Oriented Dynamic Learning Environment. This device integrates virtual learning apps and platforms, offering a novel, globally accessible tool designed to enhance learning and resource collection. NOODLE aims to promote equity by providing an affordable means for underprivileged children to engage in virtual learning, thus narrowing the digital divide.

Index Terms— Device Affordability, Digital divide, Inclusive Education, Mental Health, NOODLE, Nutrition, OBE, Virtual Learning**.**

I. INTRODUCTION

The integration of advanced wireless virtual learning and mobile technology has significantly enhanced our interactive virtual learning and communication processes. This virtual technology enables us to showcase our digital platform's opportunities and resources, marking a pivotal shift in the education landscape. The digital learning environment is now completely transformed. Students can access various types of content, including audio, video files, and text documents, through their Internet-connected mobile devices. Amid the COVID-19 pandemic, digital learning has provided valuable insights into effective student activities, supporting parents, caregivers, teachers, and school leaders in better assisting children's social, emotional, and academic needs.
This is particularly crucial in third-world and developing countries where poverty limits parents' ability to engage their children, and many children are identity-less orphans. The effort to bridge the digital divide is akin to the UN's World Literacy campaign (Reference: our work https://doi.org/10.16920/jeet/2019/v32i4/145520). Productivity in education, particularly through Outcome Based Education, remains a challenge, affecting about one-sixth of the world's children (Reference: our work https://doi.org/10.1007/s10639-019-10043-z). In our flexible and dynamic environment, cloud computing stands out as a critical issue and a significant area of research for scholars.

A. Literature Review

In primary education, one-sixth of all children globally are deprived of necessary resources (Source: GARTNER). This issue predominantly affects underprivileged communities worldwide, including those in both developing third-world countries and developed first-world nations. The situation has worsened post-pandemic, with nearly one-third of children now impacted. Contributing factors include the digital divide, malnutrition, hunger, and health concerns [1,2]. There is a pressing need to create an alternative, affordable framework to support primary education for these children.

These children lack basic amenities and a conducive environment. Poverty-stricken parents often resort to child labor to make ends meet. Music is one of the few accessible alternatives in their lives. As a universal language, music can influence human behavior and facilitate emotional adjustment [3]. Free access to music is available at platforms like (http://radio.garden/). However, language and semantics pose significant barriers. Resources for overcoming these barriers include language tools (https://www.worldlingo.com/, https://www.duolingo.com/) and semantic tools (https://www.expert.ai/blog/introduction-to-semantics/). Knowledge transfer through music in tangible forms is also possible (e.g., in India - Anganwadi, Bratachari), and this approach can have therapeutic benefits [4].

Addressing health and nutrition issues is equally important. A two-stage solution is proposed:

1. LEARN is a manual framework that uses rhymes, musical folktales, and fables in local languages to teach and engage digitally deprived children, incorporating regional semantics [5].
2. NOODLE is a virtual framework designed to bridge the digital divide for these children.

B. Music Education in Learning, Achievement, and Success

Music instruction enhances the brain areas controlling sensory and motor actions, resulting in musically trained students exhibiting superior motor skills [4,5]. Additionally, practicing music strengthens the brain regions responsible for processing complex mathematics [6]. Long-term music training improves practitioners' ability to maintain mental control during memory and recall tasks [7,8]. Studies have shown that music students have superior verbal memory recall compared to their non-music counterparts [9]. Furthermore, students engaged in music education consistently outperform their peers in math assessments, with the benefits of music education increasing over time [6]. Early childhood training in instrumental music significantly enhances attention abilities, including visual focus, active listening, and staying on task, and continued music education during adolescence further reinforces these skills [10]. Moreover, students involved in music lessons demonstrate greater perseverance in task completion compared to their peers [11].

C. Music Education in Africa

Guided Music Teaching Activities

Meki Nzewi's Approach to Teaching African Music - Nzewi (2001) [14] advocates for an African music education philosophy that integrates indigenous African models and resources into the formal music education system, emphasizing that the content and pedagogy should be rooted in African traditions.

Omollo-Ongati's Teaching Strategy for African Music - Supporting Nzewi's philosophy, Ongati (2010) [15] identifies two key pedagogical methods used in formal institutions for teaching African music: imitation, which fosters creativity, and learning through performance, which emphasizes experiential learning.

Leonhard and House's Music Education Procedures - Leonhard and House (1959) [16] propose fundamental patterns for teaching music education that include developing performance skills, fostering appreciation, enhancing knowledge and understanding, and cultivating positive attitudes.

Elliot's Music Teaching Strategies and Activities - Elliot (1995) [17] outlines six essential strategies for the musical practicum: modeling, coaching, scaffolding, articulating, comparative reflecting, and exploring.

Joyce and Weil's Instructional Models as Proposed by McNergney & Herbert - McNergney & Herbert (2001) [18] agree that there is no single best teaching method suitable for all learners and purposes. As goals and objectives evolve, instructional models must also adapt. They reference four instructional models proposed by Joyce and Weil (1998).

Fig.1. Musical Sense and Musical Meaning: an indigenous African perception
(image source:worldcat.org)

D. Music Education in Europe

The project aimed to examine how music is taught and learned in primary and secondary general schools, as well as in music teacher training programs. The goal was to clarify and make transparent the various theoretical and practical approaches to music education across Europe. Additionally, the project sought to enhance the quality of music education within school curricula and to recommend changes to both school curricula and music teacher training course content.

For further reading, see Konstantina Dogani's "Music in Schools Across Europe: Analysis, Interpretation, and Guidelines for Music Education in the Framework of the European Union," January 2011. Available at ResearchGate.

Fig.2.Europian Association for Music in school
(image source: eas-music.org)

E. Music Education in Russia

On October 1st, 2013, Mikhail Nikolaev, President of the Republic of Sakha (Yakutia), announced the launch of the republican project "Music for Everybody." In August 2015, the project received official approval and necessary support. The project aimed to use music as an educational technology to develop children's perception, consciousness, and skills. Additionally, it sought to foster a love for art and facilitate the easier understanding of school subjects such as physics, chemistry, computer science, and languages.

For more information, see Gorbunova, I.B., & Kameris, A. (2019). "Music Computer Education Concept for Teachers: Raising the Problem." International Journal of Recent Technology and Engineering, 8(2S4), 913-918.

Fig.3. Early Childhood Education Program
(image source:istockphoto.com)

F. Music Education in China:

Currently, educational innovation serves as the essential guarantee and driving force for enhancing the quality of education and overall teaching standards. This innovation is as crucial as advancements in systems and technology. It may also be the key to overcoming challenges in Chinese music education, enabling it to progress and achieve new levels of excellence. For more insights, refer to Zhou Xun's study, "Research on the Theory and Practice of the New Curriculum Music Teaching Design Innovation" (Capital Normal University, 2007).

Fig.4. Loud Mouth-The music Trust Ezine
(image source:musictrust.com)

G. Music Education in the Indian Subcontinent

Anganwadi centers employ innovative and practical methods, using the best tools creatively to fulfill their job duties. Their primary goal is to foster the development of children by teaching them essential life skills. A notable example of this resourcefulness is the translation of preschool educational methods into tribal languages in Orissa, indicating a continuous effort to adapt educational tools for various contexts, languages, and regions. Teachers at anganwadi centers assess students' needs, identifying and addressing their primary weaknesses. They must understand each child's strengths and weaknesses to implement effective measures for their growth and development (The Anganwadi Programme, n.d.). These centers offer a variety of learning experiences that engage children through visual, auditory, and physical activities.

Fig.5. Kids are at Anganwadi centers
(image source: Times of India)

Bratachari Movement: In 1928, Gurusaday Dutt, an officer in the Indian Civil Service, attended a festival organized by the English Folk Dance Society during his visit to England. He was impressed by the display of British folk traditions at the event. Inspired by this experience, he introduced a similar concept in Bengal, aiming to achieve spiritual growth through the discipline of the physical body. Rhythm was central to this movement, as the recitation of vows, prohibitions, and promises was accompanied by rhythmic body movements.

Fig.6. Bratachari Movement
(image source:wikiwand)

H. Music Education in the US

Music serves as a powerful medium for learning, offering unique ways to connect with other subject areas through its focus on fundamental learning processes, concepts, and representations that it shares with various disciplines.

Programs focused on learning through music maintain the highest standards of authentic musical education. To integrate music effectively into the elementary school curriculum, collaboration between teachers and music educators is essential. They must identify fundamental concepts that can bridge music with other academic subjects and develop interdisciplinary curriculum and evaluation practices that enhance learning for young children.

For more insights, refer to Lawrence Scripp's "Introduction: The Premise of Learning Through Music," Journal for Learning Through Music, Summer 2000.

Fig.7. Importance of learning music in the education system
(image source: Elets Technomedia)

II. AUGMENTED ISSUES

Imparting primary education to underprivileged children involves addressing two critical concerns, regardless of the educational approach through music or other means. The first is ensuring adequate nutrition, addressing their basic dietary needs. The second concern is mental health, encompassing psychological well-being.

Amidst the current shift towards virtual learning as a primary mode of education, new components and tools have been introduced to adapt to this new normal and ensure effective education delivery. However, in this post-pandemic era, health-related challenges, particularly those impacting cognitive development, pose significant threats. Research by DiGirolamo et al., 2020 [19], underscores that inadequate nutrition and early growth issues correlate with poorer outcomes in cognitive function tests, motor skills development, academic achievements, learning capabilities, and social skills.

In this evolving educational landscape, addressing mental wellness and ensuring the sustainability of education are paramount considerations. Ensuring the brain's structural integrity necessitates the intake of essential nutrients and adequate hydration, as highlighted by Roberts et al., 2022 [20]. Previous research consistently demonstrates the critical link between cognitive development and nutrition. Micronutrients such as iodine, zinc, omega-3 fatty acids, iron, and choline have been identified in studies like Nyaradi et al., 2013 [21] as crucial for neurocognitive development. Moreover, research by Ogunlade et al., 2011 [22] indicates that undernourished children who receive fortified diets exhibit improved mental processing abilities and problem-solving skills.

Meanwhile, understanding human psychology remains a primary focus across various disciplines. Extensive research and experimentation have led to new insights into cognitive processes, aiming to foster societal

advancement. The Learn with Noodle concept exemplifies a model that integrates human psychological and behavioral elements into artificial intelligence. This approach aims to provide education to economically disadvantaged children through an exclusive device-based app, thereby offering an alternative to traditional classroom-based teaching methods.

The onset of the pandemic has necessitated a shift to the "new normal," where adapting to new technological components has become essential across all socio-economic levels to ensure uninterrupted education. This phase has introduced psychological adjustments as societies and occupations embrace new knowledge-based challenges, including the teaching profession. Numerous studies support the notion that enhancing human-computer interactions can significantly reduce psychological stress [23]. Additionally, research indicates that modern teaching methods alleviate the psychological burden associated with traditional approaches, making even complex mathematical solutions more accessible [24].
However, contrasting views suggest that while artificial intelligence has rapidly expanded in higher education, it may not sufficiently develop critical thinking skills, particularly in primary education. This highlights the need for comprehensive research to refine pedagogical and ethical techniques [25]. These findings underscore the active integration of artificial intelligence into global education systems. Yet, challenges remain in providing equitable educational opportunities, especially for those for whom education remains a distant prospect, particularly in remote areas.
Understanding specific learning needs and behaviors through accurate assessment is crucial. Early research on intelligent tutoring systems and educational robots emphasizes personalized learning, including language education and emotion detection, reflecting a shift towards tailored educational experiences [26]. Furthermore, perception-based teaching is gaining importance in cognition-driven learning, necessitating detailed gap analyses between knowledge acquisition and perceptual understanding [27].
The development of AI-driven app-based learning is still evolving, particularly in addressing individual factors such as age, gender, ethnicity, socio-economic background, geographical location, and most crucially, learning aptitude and behavior. This approach holds promise in exploring new parameters that could potentially spark interest in app-based education, particularly in underserved parts of society, at least within this region of the world.

III. METHODOLOGICAL ASPECTS

Proposed Circuit Diagram of NOODLE: While it resembles a typical mobile device, our proposed research aims to enhance educational effectiveness, particularly for students in private network settings, and to make it cost-effective. The device will feature an automatic recording function for online teaching and learning sessions, ensuring that students cannot disable their audio or camera during the sessions. This automatic recording, as well as audio and camera activation, will be protected by a supervisory password. Additionally, if social applications and network activities are restricted on this educational device, data usage will be minimized, reducing network costs. This solution could significantly benefit students worldwide, especially those who are disadvantaged or overlooked, by improving access to e-learning.

A. Proposed model of Mobile Device NOODLE

Fig.8: Proposed model of Mobile Device NOODLE

- ***File Manager:*** This application assists in managing file systems. It allows users to download, copy for backup, move, rename, and delete unnecessary files. It also helps store downloaded files, documents, images, videos, and more for future use.

- ***Docs:*** A word processing application where users can write and edit text, letters, and tables, find and replace text, and utilize features like mail merge, bulleted and numbered lists, text design, and color formatting. It supports all types of documentation.
- ***Sheet:*** An electronic spreadsheet application. Users can create worksheets with calculations, graphs, auto-analysis features, and various functions for different categories.
- *Slide:* A presentation application. Users can incorporate animations, and various text styles and colors into their presentation documents.
- ***Bluetooth:*** This feature enables file transfer between devices. Students can share educational files, notes, and other important documents.
- *Video:* This application supports viewing video files such as MP3 and MP4 formats. Students can watch class recordings and educational speeches.
- ***Camera:*** Allows users to take pictures. Students can use it to photograph their notes and share them with others.
- ***Blend space:*** Blend Space is a highly effective, free web application for creating digital lessons, including interactive lessons, projects, presentations, and more. Users can sign up through the Blend Space website. It allows for the creation of lessons that combine digital content and various file types, such as Tes resources, YouTube videos, PDFs, images, PowerPoint presentations, Dropbox files, links, Word documents, and Google Drive files.
- ***Accounts:*** This application houses all setup options and is protected by a supervisory password. It allows users to input and manage device-related information. Different applications can have different password levels, including text, fingerprint, and face recognition passwords.
- ***Gallery:*** Users can view all images, videos, and documents through this application. It also allows for editing, deleting, moving, and organizing images into folders.
- ***Calculator:*** This application assists users with mathematical calculations, including scientific calculations for students.
- ***Calendar:*** Users can view current and past calendars and set events for specific dates.
- ***Drive / Cloud:*** This application allows users to store all kinds of valuable files in the cloud.
- ***Translator:*** This tool helps translate different languages, such as English to Bengali, Bengali to English, and many other language pairs.
- ***Diary:*** A tool for storing notes for various purposes, such as events, memories, quotations, and more.
- ***Recording:*** This application is used to create audio files. Students can record their own speeches or the audio from virtual classes for future reference.
- ***Classroom:*** A virtual learning platform designed for learners. It facilitates the delivery of educational content and other information without requiring physical presence. It also supports class recordings for future use, allowing participants to present their materials and share their entire screen with others in the classroom.

IV. UNITS

The prototype design for the proposed device, NOODLE, is detailed in the following sections. The circuit diagram is presented below with comprehensive information :

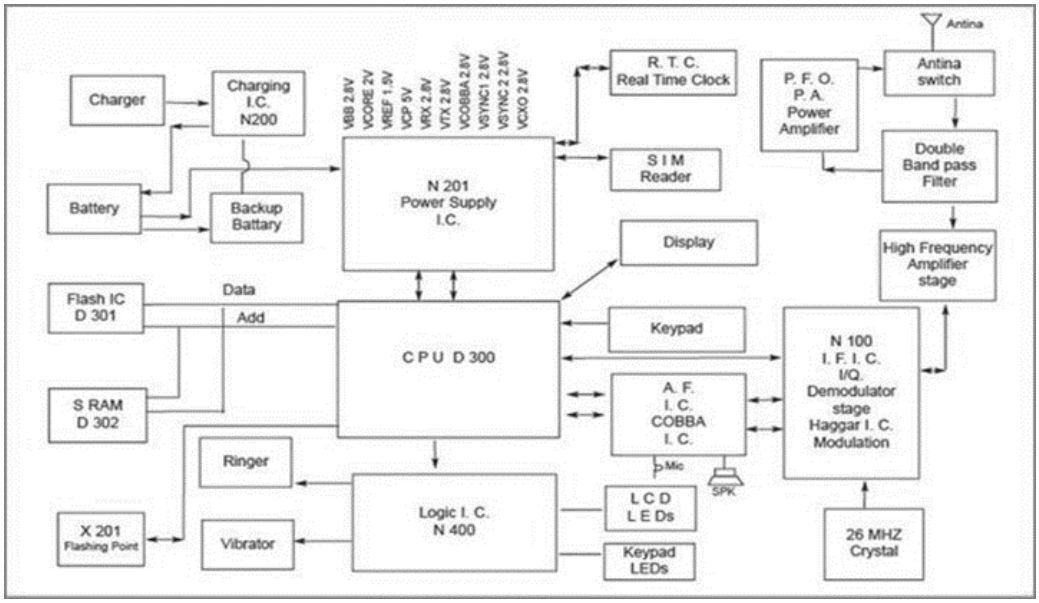

Fig.9: Proposed Circuit diagram of Mobile Device NOODLE

A. Circuit Component Details.

- **Charging IC**

The battery of the proposed device is charged when the charging IC gains current from the charger. It is located near the power section. The device will be dead or not get charged due to a short or defective Charging IC.

- Power Supply IC

This component circulates power to all the parts of the proposed device after gaining power from the battery.

- Real Time Clock

It helps us to count the pathway of time of an electronic device. RTC has a supercapacitor which is rechargeable and soldered for an alternate source of power to keep time when the main power supply is cut off. It also supplies power for the backup of RAM.

- PFO Power Amplifier

The PFO Power Amplifier amplifies the power magnitude of a signal.
It is located near the Antenna Switch. The network will be unavailable when PFO is not working properly.

- Double Band Pass Filter

A dual bandpass filter is a kind of filter that provides two different filters in the size of one filter. It allows visible light and only a special part of the visible and near-infrared spectrums for the use of the colour camera which is used in sunlight and at night.

- Antenna Switch

In this proposed device another component is Antenna Switch Modules or ASM, which is used to maintain telecommunication-related matter of smartphones and other multi-band network-connected wireless devices. It is available in metal and non-metal. It finds out the network and after tuning transmits forward.

- High-Frequency Amplifier Stage

In the communication process, the Amplifiers are the main working block. The low incoming signal into a receiver needs to be amplified to a higher value so that the signal can be identified or digitized. On the other hand, the signal requires too large for a long transmission range using free space and cables.

- IFIC I/Q Demodulator stage Haggar IC Modulation

As per the instruction of the CPU this device acts like a transmitter or receiver of audio or radio signals. This is also known as an RF signal processor.

- Crystal

This is a metal component and is also known as Network Crystal. It processes frequency at the time of outgoing calls.

- SIM Reader

It is required to establish a wireless network connection for the identification of this proposed device. It can store all personal details and configurations of this device.

- AF IC COBBA IC

It is used to maintain the Speaker and Microphone of this device. It is known as a Melody IC. In general, it presents in the power section.

- CPU

It is the brain of the proposed device, which maintains all portions of the device. It is called Central Processing Unit and is also known as RAP IC, MAD IC, and UPP.

- Logic IC

It will be used to maintain the Light Emitting Diode, Vibrator, and Ringer parts of the proposed device. If any problem in this Logic IC, then Vibrator, Ringer, and Light Emitting Diode are not working. Also, we can call it an Interface IC.

- Backup Battery

The primary power source, if unavailable, then backup battery provides power.

- Vibrator

It helps to vibrate the device. It is a very tiny motor which is a peculiar soaring weight on the axle.

- Charger

A charger reserves power in a battery by flowing an electric current through it.

- Battery

Major electronic mobiles/tabs are using Lithium-ion batteries. It supplies power to all sections of the device.

- Flash IC

Flash IC is used to store the IMEI number and Software of this device. It is also known as RAM IC, ROM IC, EEPROM IC, and Memory IC.

- ROM

It will help to install all present operating applications on a mobile device. If any error in ROM, then a software problem will arise.

- RAM

All operating commands are sent and received by the RAM of a Mobile device. If any error in RAM, then the mobile device repeatedly gets hanged.

V. Ethical Considerations

A. Data Privacy Compliance

The NOODLE device adhered to strict data privacy protocols, ensuring that user data was protected. This compliance was critical in building trust among parents and educators.

B. Ethical Implementation

Ethical considerations, such as informed consent from parents and the protection of toddler data, were rigorously followed. This ethical framework was essential for the successful deployment and acceptance of the device.

VI. Future Work

The following verticals are taken into consideration as an extension work:

Advanced sensor system

Without any indication of the user, we can track the device's location using GPS even if the device is switched off.

Continuous Improvement

Ongoing updates and improvements to the NOODLE device's security features were recommended to keep up with evolving cyber threats. Regular security audits and user feedback loops will be crucial for maintaining a secure environment.

Expansion to Other Demographics

While the device was designed for toddlers, the successful implementation suggests the potential for adapting the NOODLE device for other age groups and educational settings, with appropriate modifications to the security and usability features.

VII. Results

Research Significance – In the modern teaching and learning process, numerous alternatives have emerged. Activity-based learning is gradually replacing traditional chalk-and-talk methods. The shift from monologue to dialogue-based interactive teaching is becoming more prevalent. Today's learners are heavily influenced by hands-on learning experiences and are more autonomous in their curriculum, utilizing vast online resources like Wikipedia, YouTube, and Google. Significantly, platforms such as Blend Space, Screen Casting, and My Simple Show, which are backed by major corporations, offer customized learning aids for students. Additionally, participation in social networking enhances learners' social awareness and knowledge. However, the guidance of teachers remains crucial, as not all web content is reliable. Teachers are increasingly taking on the role of guides for their students, aligning with the Outcome Based Education (OBE) framework.

Expected Outcomes of This Model – Upon successful implementation, this model is expected to:

- Serve as an exemplary initiative for equity in child education.
- Alter the perception of education among underprivileged children.
- Bridge the gap between underprivileged and privileged children.
- Reduce the digital divide.

These efforts represent a pioneering attempt to integrate music as a large-scale educational tool.

VIII. Conclusions

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