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PROMOTING ALGORITHMIC THINKING THROUGH UNPLUGGED PRIMARY SCIENCE ACTIVITY IN RURAL SCHOOLS

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Abstract:

Algorithmic thinking, a method for solving problems through a step-by-step process that leads to a solution, is an essential component of computational thinking. Combining computational thinking and artificial intelligence (AI) in rural areas through unplugged activities provides an innovative approach to enhance science inquiry education. This article proposed the integration of algorithmic thinking and artificial intelligence (AI) within rural primary science education through hands-on, unplugged activities. Recognizing the challenges posed by limited digital access in these areas, the study introduces a model that encourages young learners to participate in STEM inquiries using practical, algorithm-oriented tasks that require little to no technology. This method promotes critical thinking, problem-solving skills, and scientific exploration by aligning with Piaget's stages of cognitive development, allowing students to interact with materials and engage in practical scenarios. Furthermore, the research emphasizes how algorithmic thinking enhances logical reasoning and STEM literacy. By incorporating interactive games such as "Algorithm Walk" and "Science Sorting Relay," the proposed model offers a contextually relevant and cost-effective approach to integrating computational thinking and fundamental AI concepts into primary education, effectively preparing students for future careers in science and technology. This would help in developing more customized, effective educational strategies and policies aimed at truly elevating meaningful educational experiences.

Keywords:

Algorithmic Thinking, Unplugged, Artificial Intelligence, Primary Science, Rural Education

Introduction

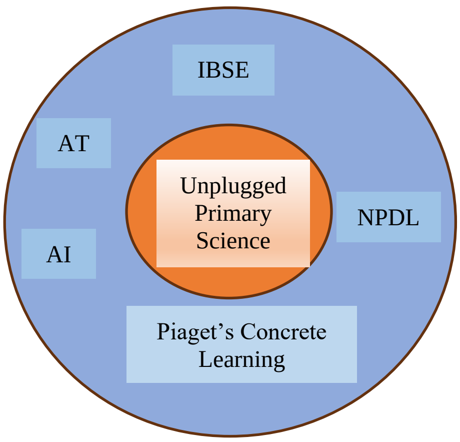
The Fourth Industrial Revolution is transforming the world of work, driven by disruptive technologies that require changes in education to prepare the workforce for the future (World Economic Forum, 2020). Integrating STEM education and computational thinking into primary education is crucial to equip students with the skills needed for innovation and systematic problem-solving (Chen et al., 2021). Combining computational thinking and artificial intelligence (AI) in rural areas through unplugged activities provides an innovative approach to enhance science inquiry education (Zhong & Xia, 2022). This approach creates flexible, engaging STEM learning experiences that foster critical thinking, problem-solving, and scientific inquiry among young learners, even in resource-limited settings.

Literature Review

Unplugged Primary Science

Artificial intelligence can be introduced at a fundamental level through unplugged and mobile activities—hands-on, tech-free, or tech-light exercises that simulate AI concepts. These activities illustrate the processes and logic behind machine learning and data-driven decision-making. Teaching students how AI systems classify objects or make predictions can be modeled with physical and mobile activities (Touretzky et al., 2019; Druga et al., 2021).

Combining algorithmic thinking with AI-focused activities involves designing classroom and mobile exercises replicating how algorithms operate in AI applications, such as data sorting and pattern recognition. This integration encourages students to understand that AI is not an abstract field but a practical tool that uses algorithms to solve problems.



Framework of Unplugged Primary Science Activities

Algorithmic Thinking

Algorithmic thinking (AT) is a set of fundamental cognitive tools and practices that originated in computing but extends far beyond computer science (CS), encompassing all disciplines. AT

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is useful in solving problems and designing systems to automate various intellectual processes. However, many projects focus on programming as a way to develop AT skills (Lye & Koh, 2014; Sengupta et al., 2013; Weintrop & Wilensky, 2017), which can limit its development as a universal skill (Voogt et al., 2015). AT can be integrated in an interdisciplinary manner and introduced to a broader group of students at an earlier age through engaging unplugged activities (Bell et al., 2009; Curzon, 2013; Jiang, 2017; Strawhacker et al., 2021; Jaipal-Jamani & Angeli, 2022). Moreover, process-based science activities that involve problem-solving in children's learning remain limited (Lee et al., 2000; Duncan et al., 2020; Papadakis, 2022). Therefore, this study proposes educational unplugged activities in science, aligned with the Standard-Based Curriculum for Primary School (KSSR), to foster intellectual growth among children in this digital age.

In Malaysia, AT integration in primary schools has been rolled out as part of the new KSSR since January 2017 (Abas, 2016). The curriculum aims to integrate AT, problem-solving, and technology across all subjects. Recent studies indicate that teachers have a limited understanding of AT (Ung et al., 2018) and require more support and guidance to effectively implement AT in their teaching (Senin et al., 2019). Additionally, science teachers need assistance in planning and designing science instruction, as well as in developing their pedagogical knowledge and skills (Osman et al., 2006; Radzi et al., 2021; Mohamad et al., 2022). Therefore, teachers should be equipped with relevant knowledge and practices specific to their teaching subjects, including strategies to integrate AT with unplugged activities into their lesson plans, activities, and assessments. This can be addressed by developing a structured educational series of activities.

Artificial Intelligence

Artificial Intelligence (AI) is increasingly being integrated into educational activities to enhance student engagement and understanding, particularly in rural and primary school settings. AI can be introduced through unplugged and mobile activities, simulating AI concepts and illustrating processes behind machine learning (Touretzky et al., 2019). Such methods provide an accessible way to introduce AI, focusing on fundamental skills like classification and prediction (Druga et al., 2021). Integrating AI with algorithmic thinking in rural schools through practical, tech-free exercises makes STEM education more inclusive and impactful, fostering essential cognitive skills even in resource-constrained areas (Rahman & Adnan, 2021). These activities not only demystify AI concepts but also encourage logical reasoning and problem-solving, preparing students for future technological advancements (Grover et al., 2020). AI-focused unplugged activities thus offer a cost-effective approach to cultivate interest in technology and computation, laying a foundation for advanced STEM learning (Zhong & Xia, 2022).

Piaget's Concrete Learning

Jean Piaget's theory of cognitive development provides a valuable framework for understanding how children learn, especially in the context of algorithmic thinking and AI education. Piaget identified four main stages of cognitive development: sensorimotor, preoperational, concrete operational, and formal operational (Piaget, 1952).

In the primary school setting, most students fall within the concrete operational stage, which typically spans from ages 7 to 11. During this phase, children develop the ability to think logically about concrete events and understand the concept of conservation. They also begin to

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grasp the concept of reversibility and can organize objects into categories and series. These skills are foundational for engaging in algorithmic thinking and problem-solving activities.

Applying Piaget's theory to the integration of algorithmic thinking and AI education implies creating learning experiences that match students' developmental stages. Unplugged activities, hands-on mobile STEM exercises, and science games align with Piaget's emphasis on active learning and discovery. Educators can promote deeper cognitive development and support the transition from concrete to more abstract thinking by allowing students to manipulate materials, observe outcomes, and refine their strategies.

For instance, games like the 'Algorithm Sequencing' or the 'Atom Sorting Relay' involve concrete tasks that require students to categorize, sequence, and follow step-by-step processes. These activities align with Piaget's view that children learn best when they can experiment and interact with their environment, fostering the construction of knowledge through direct experience.

The Importance of Algorithmic Thinking in Education

Algorithmic thinking is a systematic approach to problem-solving that involves breaking down complex tasks into smaller, logical steps (Wing, 2006). It supports logical reasoning and structured problem-solving, making it a key component of computational thinking. In the context of primary science inquiry, algorithmic thinking can guide students through the scientific method: posing questions, making observations, hypothesizing, experimenting, and drawing conclusions (Grover & Pea, 2013).

Research has shown that algorithmic thinking enhances students' ability to deconstruct problems into manageable parts, aligning well with inquiry-based science education (Lockwood & Mooney, 2018). For rural primary schools with limited access to technology, introducing algorithmic thinking through unplugged and mobile activities can serve as a cost-effective and impactful way to develop these critical cognitive skills.

Algorithmic thinking is essential in science education due to its multifaceted benefits in fostering critical cognitive skills, problem-solving abilities, and deeper comprehension of scientific concepts. Algorithmic thinking equips students with the ability to approach problems methodically, breaking them down into manageable steps and developing step-by-step solutions. This structured way of thinking is particularly valuable in scientific investigations where complex problems must be deconstructed for analysis (Wing, 2006). Engaging with algorithms and computational processes strengthens students' logical reasoning. In science education, this type of reasoning supports hypothesis formulation, experimental design, and data analysis (Grover & Pea, 2013). Algorithmic thinking is a cornerstone of computational thinking, which is increasingly recognized as fundamental for STEM literacy. It prepares students for future careers in science and technology fields where coding, data analysis, and model simulation are essential skills (Weintrop et al., 2016). The principles of algorithmic thinking are applicable beyond computer science, enhancing teaching and learning in various scientific domains, including biology, physics, and chemistry, by fostering a mindset that can systematically explore and solve scientific problems (Basu et al., 2021). Development of Abstract Thinking: Algorithmic thinking nurtures the ability to conceptualize complex processes at a higher level of abstraction. This skill is crucial in science education, where

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students must grasp intricate concepts such as chemical reactions or ecological systems (Lye & Koh, 2014).

New Pedagogies for Deep Learning (NPDL)

This element emphasizes collaborative, student-centered learning experiences aimed at developing critical thinking, creativity, and problem-solving skills. These approaches engage students in real-world tasks that are relevant and meaningful, often incorporating technology as a tool for exploration and collaboration. By focusing on student agency and authentic learning experiences, deep learning prepares learners for complex challenges (Fullan et al., 2021). Meaningful learning is when students use the knowledge and content skills they have acquired to explore and create new knowledge and skills and ideas. Through the new knowledge and skills gained, students use them to solve problems in life. Meaningful learning involves the process of students achieving their Global 6C competencies by utilizing digital tools and resources. In order to achieve meaningful learning, the new pedagogy needs to emphasize the ability of students to use content knowledge to create and produce new knowledge that can be utilized in their lives. Teachers and students jointly explore the content. The use and utilization of technology is ' ubiquitous' (learning happens everywhere).

Inquiry-Based Science Learning (IBSL)

IBSL incorporating the 5E model—Engage, Explore, Explain, Elaborate, and Evaluate—encourages students to engage deeply with scientific concepts. In this model, students first engage with a scientific phenomenon, explore it through hands-on activities, explain their findings, elaborate by applying concepts in new situations, and evaluate their understanding. This approach promotes curiosity, critical thinking, and hands-on discovery, allowing students to build a deep understanding of scientific concepts (Zhong & Xia, 2022).

The 5E instructional model—Engage, Explore, Explain, Elaborate, and Evaluate—provides a structured approach to inquiry-based science learning. According to Banchi and Bell (2008), there are four levels of inquiry: confirmation, structured, guided, and open. In confirmation inquiry, students confirm a principle through an activity with a known outcome, reinforcing specific concepts. Structured inquiry involves students investigating a teacher-presented question through a prescribed procedure, allowing them to build foundational inquiry skills. Guided inquiry requires students to design their own procedures to explore a teacher-presented question, fostering deeper engagement and critical thinking. Open inquiry empowers students to formulate their own questions and procedures, promoting autonomy and advanced inquiry skills. Integrating the 5E model with these levels of inquiry enables educators to scaffold instruction effectively, gradually releasing responsibility to students as they develop the skills necessary for independent scientific investigation.

Methodology

This study focused on children aged 11 years. According to Piaget's stages of development, children at the concrete operational stage are capable of forming concepts, recognizing relationships, and solving problems, but only when these involve familiar objects and situations (Slavin, 2009; Daniels, 2021).

Fun Algorithmic Science Games and Mobile STEM Activities

Introducing algorithmic thinking through science-based games and mobile STEM activities can make learning engaging and interactive. Here are two activities using the approach of fun,

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unplugged games and mobile activities that can help students develop algorithmic thinking skills in rural settings:

Activity 1: Atom Sorting Relay (Unplugged):
Objective: Teach students classification and sorting algorithms.
Materials: Cards with images or descriptions of different objects (e.g., types of plants, rocks, or animals).
How to Play: Divide students into teams. Each team is given a set of cards and must sort them according to specific rules (e.g., by habitat, size, or shape). The first team to correctly sort their set wins.

Activity 2: Algorithm Sequence (Unplugged):
Objective: Practice step-by-step logical thinking.
Materials: A simple grid drawn on the ground or a large piece of paper with obstacles.
How to Play: One student acts as the 'robot,' and another student provides step-by-step instructions to move the 'robot' from start to finish, avoiding obstacles.

Conclusion

Unifying algorithmic thinking with unplugged and mobile STEM activities through fun science games effectively enriches science inquiry education in rural primary schools. By using algorithm-focused and mobile activities, students gain an early understanding of AI and its real-world applications, equipping them with essential skills for the 21st century.

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