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Abstract

In an era of constant digital distractions, maintaining attention is a growing challenge for young students. This paper explores how STEM education and AI-driven learning tools can enhance attention skills by fostering problem-solving, analytical thinking, and cognitive endurance. STEM disciplines require sustained focus, while AI-powered adaptive learning platforms personalize experiences, track attention patterns, and provide real-time feedback to optimize engagement. By integrating structured education, technology, and cognitive strategies, this study highlights the critical role of STEM and AI in strengthening attention control, ensuring better academic performance and long-term cognitive resilience.

Introduction

The ability to concentrate is a fundamental skill for learning, yet it is increasingly challenged by contemporary distractions. The omnipresence of digital devices, cognitive overload, and the pursuit of instant gratification all fragment students' ability to focus, thereby diminishing their capacity for memory retention and deep thinking (Klingberg, 2009). Given these challenges, it is crucial to implement educational strategies that enhance focus and minimize interferences. Teaching students to manage their attention consciously is essential for their academic success and cognitive development (Posner & Rothbart, 2007).

Modern distractions are omnipresent, particularly affecting younger generations. Between incessant smartphone notifications, the constant presence of social media, and an overwhelming influx of information, students are perpetually bombarded with stimuli that compete for their attention (Gazzaley & Rosen, 2016). However, concentration is an essential cognitive function that enables deep reasoning, problem-solving, and long-term knowledge retention. The overuse of digital tools, while beneficial for educational purposes, often leads to negative consequences. Smartphones, tablets, and computers serve as gateways to information, yet they also introduce numerous distractions such as social media, gaming, and streaming platforms (Junco & Cotten, 2012). These elements fragment attention and make it harder for students to sustain focus over extended periods. Research indicates that multitasking with digital devices is associated with increased cognitive load, leading to greater distractibility and reduced capacity for in-depth comprehension (Moisala et al., 2016).

Another significant factor is the structure of social media, which thrives on mechanisms of instant gratification. Applications such as Instagram, TikTok, and Snapchat are designed to capture and maintain users' attention through likes, comments, and continuous content scrolling (Smallwood & Schooler, 2015). This constant cycle of engagement makes it difficult for students to commit to long, intellectually demanding tasks. Frequent switching between digital entertainment and academic work fosters mind-wandering, reducing the ability to engage in deep, reflective thinking. Similarly, the phenomenon of information overload, facilitated by unlimited access to online content, overwhelms working memory and makes it difficult for students to filter relevant knowledge from unnecessary distractions (Klingberg, 2009). Rather than encouraging deeper analysis, this abundance of information often results in fragmented learning, where knowledge is absorbed superficially without being integrated into long-term memory (Gazzaley & Nobre, 2012).

The consequences of this decline in attention span are significant. Research has demonstrated that frequent interruptions reduce students' capacity to maintain focus, leading to lower academic performance (Kahneman, 1973). Attention is a limited cognitive resource, and every distraction depletes it, making the learning process less efficient. The ability to retain information also suffers, as fragmented attention weakens the processes required for encoding and consolidating knowledge into long-term memory (Broadbent, 1958). Furthermore, the erosion of focus affects students' capacity for critical thinking. Constant exposure to short bursts of content promotes rapid, passive consumption rather than deep, analytical engagement. This cognitive shift prioritizes quick processing over complex reasoning, leading to a decline in students' ability to critically assess information (Gazzaley & Rosen, 2016).

To navigate this complex landscape, young people must cultivate the ability to discern what truly matters. This requires a form of modern stoicism—a disciplined approach to external influences, where individuals learn to prioritize their goals over distractions (Holiday, 2019). The capacity to remain focused, to filter out unnecessary noise, and to dedicate time to genuine self-improvement is becoming an increasingly rare but essential skill. Rather than being pulled in multiple directions by the constant demands of the digital world, young people must develop strategies to remain grounded, whether through mindfulness practices, disciplined time management, or a commitment to long-term goals (Posner & Rothbart, 2007).

Training students in mindfulness and cognitive control techniques can significantly improve their ability to filter distractions and maintain focus (Diamond, 2013). Research has shown that practices such as meditation and structured cognitive exercises enhance executive functions, reinforcing concentration and self-discipline (Van Zomeren & Brouwer, 1994). Beyond personal training, external measures should be implemented to regulate the use of technology in educational environments. Schools can enforce policies to limit smartphone use in class, while parents can play a crucial role in moderating screen time at home (Moqbel & Kock, 2018). Digital detox periods have been shown to improve cognitive endurance and overall mental well-being (Gazzaley & Rosen, 2016). Additionally, adopting innovative teaching methodologies that promote active learning can help maintain student engagement. Methods that emphasize hands-on experimentation, collaborative projects, and autonomy have been found to encourage deeper focus and sustained attention, making it easier for students to absorb and retain knowledge (Lachaux, 2015).

In conclusion, modern distractions pose significant challenges to students' ability to concentrate, impacting their academic performance and cognitive development. However, by fostering mindful attention management, regulating the use of digital technology, and adopting pedagogical approaches that promote engagement, it is possible to mitigate these negative effects. The ability to focus is not just crucial for academic success but also for lifelong learning, professional competence, and overall intellectual development in an era increasingly defined by constant digital stimulation (Holiday, 2019).

The aim of this paper is to study and investigates the role of Science, Technology, Engineering, and Mathematics (STEM) education and Artificial Intelligence (AI)-driven learning platforms in enhancing attention skills. STEM disciplines require deep problem-solving, analytical thinking, and sustained mental effort, training students to maintain focus for extended periods. AI-powered adaptive learning tools further optimize cognitive engagement by personalizing learning experiences, tracking attention patterns, and offering real-time feedback to reinforce concentration.

The paper also discusses theoretical perspectives on attention, including William James' cognitive model, Ribot's theory of voluntary attention, and Broadbent's attention filter model, illustrating how cognitive psychology provides insights into maintaining sustained focus. Additionally, it examines empirical research on attention deficits, such as ADHD, and explores interventions such as the ATOLE program, which promotes structured attention training in educational settings. Ultimately, the ability to navigate distractions and sustain deep focus will define success in the 21st century, making attention management an indispensable skill for future generations.

The Concept of Attention and Its Role in Cognitive Development

Attention is a fundamental cognitive process that enables individuals to selectively focus on relevant stimuli while filtering out extraneous distractions (Posner & Rothbart, 2007). It is the gateway to learning, allowing the mind to process, store, and retrieve information effectively. Without attention, concentration becomes fragmented, and the ability to retain knowledge is significantly impaired. The human cognitive system is designed to channel focus toward specific tasks while ignoring irrelevant information, thereby optimizing learning and performance (Gazzaley & Rosen, 2016).

The concept of attention is multifaceted, encompassing various dimensions such as selective attention, sustained attention, and divided attention. Selective attention, or focused attention, is the ability to concentrate on a particular stimulus while disregarding competing distractions (Broadbent, 1958). This is particularly crucial in an educational setting, where students must focus on lessons while ignoring background noise or other sensory inputs. Sustained attention refers to the capacity to maintain focus over an extended period, which is essential for completing long-term tasks such as reading, problem-solving, or engaging in complex reasoning (Van Zomeren & Brouwer, 1994). Divided attention, often termed multitasking, is the ability to manage multiple streams of information simultaneously, though research suggests that excessive multitasking can reduce cognitive efficiency (Moisala et al., 2016).

The brain's cognitive system consists of various functions that allow individuals to interact effectively with their environment. These cognitive functions include attention, memory, executive functions, social cognition, visuospatial abilities, and language processing (Diamond, 2013). Attention serves as the foundation upon which these other functions operate. Without the ability to focus, memory retention diminishes, executive decision-making becomes impaired, and cognitive adaptability is weakened (Klingberg, 2009).

Memory, in particular, plays a crucial role in the learning process. It is broadly categorized into sensory memory, short-term memory, and long-term memory (Posner & Rothbart, 2007). Sensory memory captures immediate sensory information, short-term memory temporarily holds information for processing, and long-term memory stores knowledge indefinitely. Teachers aim to enhance long-term memory retention in students, which requires them to be attentive during lessons, filtering out distractions and engaging deeply with the material (Gazzaley & Nobre, 2012).

Theoretical Models and the Evolutionary Perspective on Attention

Philosophers and psychologists have long debated the nature of attention. In the late 19th century, Théodule Ribot proposed that attention exists in two distinct forms: spontaneous (natural) attention and voluntary (artificial) attention (Ribot, 1889). Spontaneous attention arises instinctively when an individual encounters stimulus that evoke emotional responses, while voluntary attention requires conscious effort and training. Ribot argued that voluntary attention is an acquired skill, cultivated through education, discipline, and external conditioning. He emphasized that attention operates like a muscle that strengthens with repeated use and exercise. By nature, it is precarious and unstable, drawing its strength from spontaneous attention, which serves as its sole foundation. It is merely a tool of refinement and a product of civilization (James, 1890).

Attention, in both its forms, is not an indeterminate activity, a sort of "pure act" of the mind operating through mysterious and elusive means. Even at a general level, we can define attention as the temporary cessation of the continuous flow of thoughts, sensations, and ideas, focusing entirely on one dominant state of consciousness (Cherry, 1953). However, this does not imply a total exclusion of all other mental activity; rather, it means that one dominant idea attracts all related thoughts while limiting irrelevant associations. In essence, attention channels all available cognitive energy toward a single focal point (Broadbent, 1958).

William James further expanded on this concept in his seminal work The Principles of Psychology (1890), where he described attention as the mind’s ability to focus on a particular thought or stimulus amidst competing distractions. James likened the flow of consciousness to a river, with moments of clarity (places of rest) and periods of rapid thought progression (places of flight). He posited that memory and attention are closely intertwined, with attention playing a critical role in reinforcing recollection. His distinction between primary (immediate) memory and secondary (reproductive) memory highlights how attention facilitates the retention and retrieval of past experiences (James, 1890).

Cognitive scientists have long sought to understand the mechanisms underlying attention. One prominent model is the framework proposed by Van Zomeren and Brouwer (1994), which distinguishes between two primary domains of attention: intensity and selectivity. Intensity pertains to an individual's ability to maintain concentration on a single task over time and includes aspects such as alertness, vigilance, and sustained attention (Klingberg, 2009). Alertness involves responding quickly to stimuli, vigilance refers to maintaining cognitive efficiency during prolonged tasks, and sustained attention is required for activities demanding continuous focus. Selectivity, on the other hand, encompasses selective and divided attention. Selective attention is the ability to concentrate on a single task despite external distractions, whereas divided attention involves focusing on multiple stimuli simultaneously (Moisala et al., 2016). Both are essential for effective learning and problem-solving.

The Role of Attention Filtering in Cognitive Processing

In the mid-20th century, cognitive psychologists Colin Cherry and Donald Broadbent introduced the concept of the "attention filter," which suggests that the brain selectively processes information while disregarding irrelevant stimuli (Cherry, 1953; Broadbent, 1958). Cherry's cocktail party effect demonstrated that individuals can focus on a single conversation in a noisy environment, filtering out competing voices. Broadbent's model expanded on this idea by proposing that attention operates as a selective channel, allowing only pertinent information to pass into short-term memory. This filtering mechanism is crucial in educational settings, where students must concentrate on relevant material while blocking out distractions.

Strategies for Enhancing Attention in Education

Given the importance of attention in learning, educational interventions have been developed to help students improve their focus. One such initiative is the ATOLE program (ATtention à l'écOLE), designed by neuroscientist Jean-Philippe Lachaux (Lachaux, 2015). This program educates students on the mechanics of attention, helping them recognize and manage internal and external distractions. Through structured activities, students learn to stabilize their focus, regulate cognitive engagement, and develop resilience against interruptions.

Educators play a pivotal role in guiding students through these strategies, ensuring they can apply them effectively in academic and real-world settings. Research has shown that mindfulness training, structured cognitive exercises, and self-discipline techniques significantly enhance executive functions, improving both attention and learning outcomes (Diamond, 2013).

ATOLE: A Ten-Step Program

Step	Title	Description
Step 1	Discovering Attention	Learning to master one's attention to establish focus and engagement.
Step 2	Attentional Balance	Understanding that following a clear direction and path helps maintain attentional stability.

Step	Title	Description
Step 3	The Brain and Neurons	Gaining knowledge of brain functions and how attention operates neurologically.
Step 4	Neurons and Distraction	Identifying external factors that disrupt attention and create cognitive overload.
Step 5	Neurons and Concentration	Learning how key neurons work to retain information effectively.
Step 6	Maximoi and Minimoi	Breaking down complex tasks into manageable micro-tasks to sustain focus.
Step 7	Reacting to External Distractions	Learning to recognize and autonomously manage external distractions.
Step 8	Reacting to Internal Distractions	Developing skills to control internal distractions, such as intrusive thoughts.
Step 9	Focusing on Physical Activities	Utilizing Perception, Intention, and a Method (PIM) to maintain concentration on simple physical tasks.
Step 10	Focusing on Mental Activities	Understanding the difference between a physical PIM and an intellectual PIM for cognitive focus.

Modified ATOLE Table: A New Approach to Attention Management in the Digital Era

The Modified ATOLE Table is an updated framework designed to address the evolving challenges posed by digital distractions and modern cognitive overload. While the original ATOLE program focused on attention management in traditional learning environments, this revised version integrates strategies tailored to the digital age, emphasizing focus, resilience, and cognitive endurance.

Key Components of the Modified ATOLE Table

Awareness of Digital Overload: The first step in managing attention in a hyperconnected world is recognizing how excessive information intake and social media consumption impact cognitive processes. Understanding the psychological and neurological consequences of digital overload enables students to take proactive measures in regulating their screen time and engagement with technology.

Setting Clear Priorities: Digital distractions often obscure meaningful goals. This step encourages students to filter out unnecessary digital content, define clear objectives, and allocate attention to high-value activities. Techniques such as time-blocking, the Eisenhower Matrix, and focus-driven goal setting help individuals prioritize effectively.

Strengthening Cognitive Endurance: The constant exposure to short-form content weakens the brain’s ability to sustain attention over long periods. Cognitive endurance training includes methods like deep work, Pomodoro techniques, and incremental attention-building exercises, reinforcing the ability to stay focused for extended durations.

Managing Social Media Influence: Social media fosters addictive engagement loops, contributing to anxiety, comparison fatigue, and fragmented focus. This step emphasizes digital literacy, self-regulation strategies, and tools such as app usage tracking, content curation, and mindful engagement with online platforms.

Training Selective Attention: Selective attention is the ability to concentrate on relevant information while ignoring distractions. Training techniques such as meditation, attentional control exercises, and structured cognitive games help refine the ability to focus on one task at a time despite external noise.

Micro-Tasking for Efficiency: Multitasking is a cognitive burden that reduces efficiency and comprehension. Instead of multitasking, this step advocates for micro-tasking, where students break large projects into smaller, manageable tasks, reducing cognitive overload and enhancing productivity.
Reacting to External Stimuli: In highly stimulating environments, attention can be easily hijacked by sounds, visuals, and other distractions. Developing adaptive focus strategies, such as situational awareness, environmental adjustments, and self-imposed digital boundaries, helps students maintain attention amidst distractions.

Controlling Internal Disruptions: Internal distractions, such as intrusive thoughts, stress, and mental fatigue, hinder sustained focus. This step integrates mindfulness techniques, controlled breathing, and structured cognitive breaks to reduce internal mental clutter and improve attentional stability.

Digital Detox Strategies: A periodic disconnection from screens is crucial for cognitive restoration. This step encourages scheduled digital detox periods, offline hobbies, nature exposure, and strict device-free zones, helping the brain reset and recharge.

Building Long-Term Focus Habits: Developing sustainable attention skills requires continuous practice. This final step promotes habit formation techniques such as self-monitoring, attention tracking, and commitment to long-term cognitive health strategies, ensuring that attentional discipline becomes an ingrained skill rather than a temporary adjustment.

Impact and Relevance of the Modified ATOLE Framework

The Modified ATOLE Table offers a structured, science-backed approach to combating digital-era distractions, fostering resilience, and reinforcing attention control. By integrating behavioral psychology, cognitive neuroscience, and educational strategies, this framework provides a comprehensive roadmap for improving concentration, reducing cognitive fatigue, and developing lifelong focus habits.

Application in Education and Professional Settings

- For Students: Helps manage distractions, improves academic performance, and supports deep learning.
- For Educators: Offers a structured approach to teaching attention control and digital discipline.
- For Professionals: Enhances productivity, minimizes work-related distractions, and fosters deep work

habits.

By addressing the unique attention challenges of the digital era, the Modified ATOLE framework equips individuals with the necessary cognitive tools to thrive in an age of information overload.

Modified ATOLE Table: Addressing Digital Distractions and Modern Challenges

Step	Title	Description
Step 1	Awareness of Digital Overload	Understanding how excessive information and social media impact focus.
Step 2	Setting Clear Priorities	Learning to filter distractions and define meaningful objectives.
Step 3	Strengthening Cognitive Endurance	Developing mental resilience to sustain focus for extended periods.
Step 4	Managing Social Media Influence	Recognizing and mitigating the psychological effects of digital interactions.
Step 5	Training Selective Attention	Practicing techniques to maintain deep focus amidst digital noise.
Step 6	Micro-Tasking for Efficiency	Adopting structured workflows that enhance productivity without cognitive fatigue.
Step 7	Reacting to External Stimuli	Learning to adapt and maintain attention despite a high-stimulation environment.
Step 8	Controlling Internal Disruptions	Implementing mindfulness techniques to manage stress and mental clutter.
Step 9	Digital Detox Strategies	Establishing routines to disconnect from screens and restore cognitive balance.
Step 10	Building Long-Term Focus Habits	Creating sustainable habits for lifelong attention control and self-discipline.

The Role of STEM and AI

In an era dominated by digital distractions and diminishing attention spans, the ability to concentrate has become a crucial cognitive skill (Gazzaley & Rosen, 2016). Science, Technology, Engineering, and Mathematics (STEM) education, alongside advancements in Artificial Intelligence (AI), plays a significant role in cultivating this skill, as it demands analytical thinking, problem-solving, and sustained mental effort (Posner & Rothbart, 2007). Through rigorous problem-solving, hands-on experimentation, and AI-driven learning tools, STEM fosters deep concentration and enhances cognitive endurance (Diamond, 2013). Engaging in STEM disciplines not only strengthens the capacity for focus but also contributes significantly to academic and professional success.

Concentration is the foundation of effective learning, enabling individuals to absorb, process, and apply information efficiently. Without focused attention, retaining complex concepts and solving intricate problems becomes nearly impossible (Klingberg, 2009). Research in cognitive science suggests that concentration is akin to a muscle that strengthens with regular use (Posner & Rothbart, 2007). Activities that challenge the brain and require sustained focus, such as those found in STEM fields, help improve this skill over time. AI-powered learning platforms further enhance this process by providing adaptive, personalized learning experiences that help students maintain engagement and minimize distractions (Luckin et al., 2016).

STEM and AI as Cognitive Enhancers

One of the key ways STEM and AI enhance concentration is through problem-solving and logical analysis. STEM disciplines frequently require individuals to tackle complex problems in a structured manner, whether it involves solving mathematical equations, debugging a computer program, or designing an engineering solution (Mayer, 2004). These tasks necessitate deep cognitive engagement, training the brain to sustain attention over long periods. AI-powered tutoring systems can assess student progress in real-time, providing tailored exercises to reinforce focus and problem-solving skills (Luckin et al., 2016).

Hands-on experimentation in science and engineering also reinforces the ability to concentrate. A chemistry experiment, for instance, requires precise measurements and careful observation, demanding meticulous attention to detail (Chi & Wylie, 2014). By engaging in these processes, students develop their ability to focus on minute details and follow a sequence of logical steps to reach an outcome.

Coding and Mathematics: A Mental Endurance Test

Computer science and programming further strengthen cognitive endurance by requiring prolonged engagement with coding syntax, debugging, and algorithmic problem-solving (Shute et al., 2017). Writing code not only demands technical proficiency but also patience and persistence, as errors and failures are inevitable. Successfully debugging code requires individuals to analyze multiple variables, track logical flaws, and sustain focus despite frustration (Pea & Kurland, 1984). AI-driven coding assistants can help students stay engaged by providing real-time feedback and step-by-step debugging guidance, reinforcing their ability to concentrate and persist through challenges (Luckin et al., 2016).

Similarly, mathematics, a core component of STEM, builds mental stamina through logical sequencing and problem-solving (Mayer, 2004). Working through mathematical proofs, calculations, and statistical analyses requires sustained attention, reinforcing the ability to remain focused over long durations. AI-based math tutors can provide personalized problem sets that adapt to a student's learning pace, encouraging deep engagement with mathematical concepts (Chi & Wylie, 2014).

AI and Cognitive Optimization

Beyond technical expertise, STEM education combined with AI enhances broader cognitive functions such as attention control, critical thinking, and adaptability (Luckin et al., 2016). AI-powered learning platforms can track student attention patterns and suggest focus-improving strategies tailored to individual learning styles (Gazzaley & Nobre, 2012). Engaging with STEM subjects and AI-driven adaptive learning tools conditions the brain to work through challenges systematically, strengthening mental resilience (Shute et al., 2017). Numerous studies have shown that individuals who consistently engage in STEM-related activities exhibit improved concentration, better memory retention, and higher problem-solving abilities compared to those who do not (Pea & Kurland, 1984). The rigorous and structured nature of STEM learning fosters disciplined thinking, enabling individuals to maintain focus even in high-pressure situations (Klingberg, 2009).

The Real-World Implications of Focus Enhancement

The benefits of enhanced concentration extend beyond academic performance into professional and everyday life. Many careers in STEM, such as engineering, scientific research, and data analysis, require individuals to apply sustained attention to complex problems (Mayer, 2004). AI-driven work environments demand strong focus and problem-solving capabilities, making the ability to concentrate a key asset in the digital age (Luckin et al., 2016). Professionals in these fields must analyze data, design solutions, and innovate, all of which require deep cognitive engagement (Diamond, 2013). The ability to concentrate is also invaluable in daily life, from managing tasks efficiently to making informed decisions. In a world filled with distractions, the cognitive discipline developed through STEM and AI provides individuals with a competitive advantage, helping them navigate challenges more effectively (Gazzaley & Rosen, 2016).

Finaly, STEM education and AI technologies provide innovative solutions to support students with Attention Deficit Hyperactivity Disorder (ADHD) by enhancing focus, engagement, and cognitive control. STEM-based learning incorporates hands-on, interactive activities such as coding, robotics, and scientific experiments, which help sustain attention by leveraging multisensory engagement and gamification. AI-powered personalized learning platforms adapt lessons to individual needs, offering real-time feedback, microlearning approaches, and tailored content adjustments that accommodate ADHD learning styles.

Additionally, AI-driven tools like brain-computer interfaces, eye-tracking systems, and cognitive training apps improve attention span and executive function by monitoring engagement and providing biofeedback. AI also enhances classroom support through speech-to-text applications, virtual tutoring assistants, and structured task management tools, helping ADHD students stay organized and focused. Furthermore, AI-powered mindfulness applications and Virtual Reality (VR) simulations aid in emotional regulation and attention training by creating immersive, structured environments. By integrating these STEM and AI-driven strategies, students with ADHD can develop stronger concentration skills, improve academic performance, and build long-term cognitive resilience.

Activities and Experimentations in Class

In this section, we present a classroom activities designed to teach mathematics to primary school students by integrating STEM and machine learning. These activities emphasize hands-on problem-solving, pattern recognition, and the exploration of technology. They are implemented in primary school settings in collaboration with a team of teachers.

Table 1. List of Materials and Detailed Steps for Implementing the "Build a Shape Sorting Machine" Activity in Classrooms

Activity Title	**Build a Shape Sorting Machine**
Objective	Teach students geometric concepts, sorting, and classification through a simple machine-learning model that recognizes shapes.
Materials Needed	• Geometric shape cut-outs (circle, square, triangle, rectangle) • Computers/tablets (for using a basic machine learning tool like Teachable Machine) • Paper and markers for creating additional shapes
Steps	
1. Introduction to Geometric Shapes (10-15 min):	• Discuss basic shapes and their properties (e.g., sides, corners).
2. Shape Classification (15-20 min):	• Draw or use pre-cut shapes, then classify them by properties.
3. Train the Machine to Sort Shapes (20-30 min):	• Upload shape images to a tool like Teachable Machine, train it, and test with new shapes.
4. Discussion (10-15 min):	• Reflect on the process, challenges, and importance of shapes in daily life (e.g., architecture, design).
Mathematical Concepts	• Geometry (shapes, sides, angles) • Classification and sorting • Visual patterns and recognition

Experimentation of Build a Shape Sorting Machine

In the following, we describe a study involving 28 participants from a preschool class. Among the 28 participants, none exhibited specific characteristics or had defined and/or diagnosed special educational needs. The participants were randomly divided into two groups of 14 students each, forming a control group and an experimental group. The selection was made via a lottery system while ensuring gender parity with 7 girls and 7 boys in each group. The class originally consisted of 31 students, but three students were not present as the experimentation was conducted in the afternoon.

Participants in the control group engaged in three math reinforcement workshops focusing on manipulation skills, including estimating quantities (few/many), recognizing round shapes, and making one-to-one correspondences using digital representations. For the experimental group, these same workshops were presented as challenges hidden around the classroom. Students located them using clues designed for shape-learning games in an AI-enhanced (machine learning) environment. Solving the challenges aimed to "free" the class mascot (see Table 1). All materials used were familiar to the students to avoid a novelty effect that could distract them from the task. These included classroom objects like round-shaped items and tokens (see Fig1).

An observation grid was designed to collect data uniformly across both groups. Key indicators included success in tasks or challenges categorized as "acquired," "in progress," or "not acquired" for each skill evaluated; attention and motivation assessed subjectively on a three-level scale (low, medium, high); and spontaneous participation and peer interactions measured by the number of verbal exchanges, categorized into low (0--2 exchanges), medium (2--4 exchanges), or high (more than 4 exchanges). Observations were recorded in real-time using these grids, and recordings were reviewed to refine notes. Students were informed of the recordings, which were discreetly conducted.

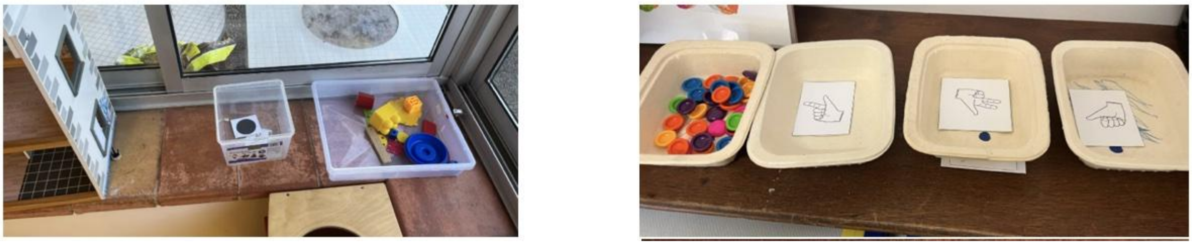

Figure 1a. Activity Items

Figure 1b. Activity Items for the AI Group

The materials for the workshops included items already familiar to the students to avoid a novelty effect that could distract them from the task. These included various classroom objects, some of which were round, tokens, and items for counting (see Figure 1a). For the AI group, we designed additional cards for machine learning-based activities that provided clues to help free the mascot (see Figure 1b).

The experimental group sessions maintained an immersive nature, with challenges linked to a narrative goal of freeing the mascot. In contrast, the control group was explicitly told they were practicing previously learned math concepts. Both groups followed a fixed activity order--estimating quantities, recognizing shapes, and making one-to-one correspondences. The sessions lasted approximately 15 minutes for traditional workshops and 20 minutes for the experimental challenges. Feedback for the control group included discussions on the correctness of responses, while the experimental group used breaks between challenges to search for the next one using obtained clues.

Data were processed using Excel for coding and organization and Jamovi software for statistical analysis. Indicators were converted into numerical values for statistical treatment: task success (0 = "not acquired," 1 = "in progress," 2 = "acquired"); attention and motivation (0 = low, 1 = medium, 2 = high); and participation and peer interactions (0 = low, 1 = medium, 2 = high). This transformation facilitated comparison between the two groups. The study aimed to assess the impact of AI-enhanced activities on the reinforcement of mathematical concepts in preschool. The hypotheses suggested that AI-driven activities would increase student engagement, leading to better understanding and retention of mathematical concepts. Results showed that students in the experimental group demonstrated significantly higher engagement. Attention reached a "high" level for 43% of the experimental group compared to 29% in the control group (see Figure 3).

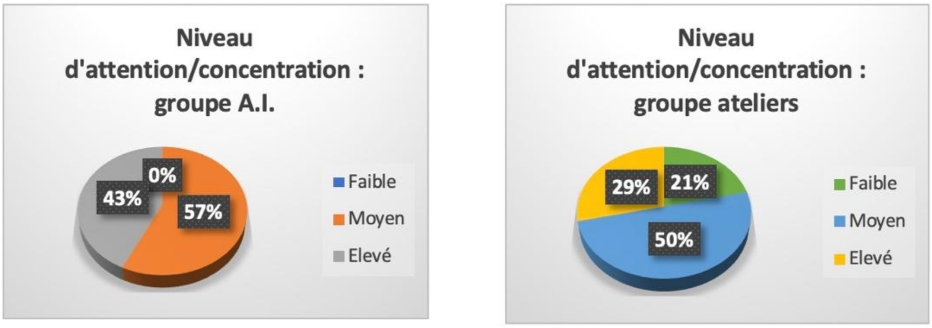

Figure 3. Distribution of Attention Levels in Control and Experimental Groups as Observed during the Study

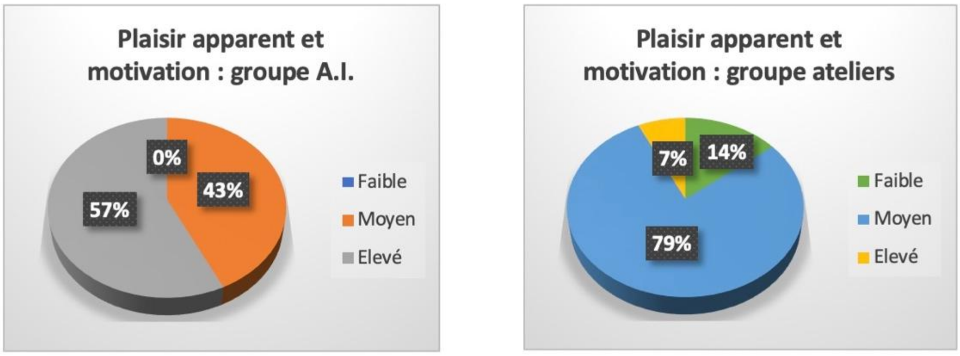

Figure 4. Comparative Analysis of Motivation Levels between the Control and Experimental Groups

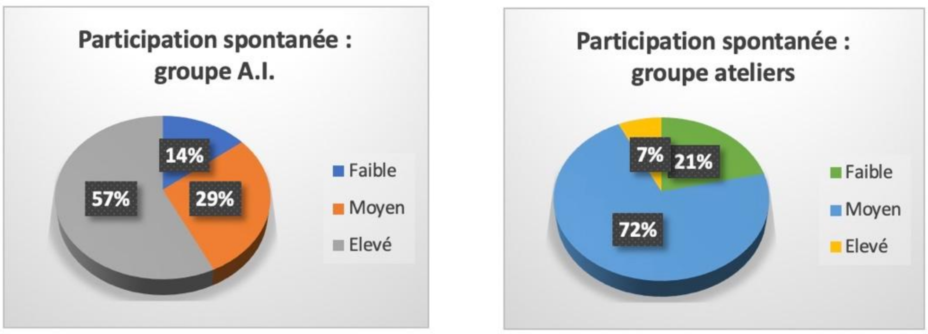

Figure 5. Observed Levels of Peer Interaction Measured by Verbal Exchanges in Control and Experimental Groups

Motivation and apparent enjoyment were higher for 57% of the experimental group compared to just 7% of the control group, with a significant difference confirmed by a T-test ($t(26) = -3.44$, $p < 0.001$) (see Figure 4). Similarly, participation and peer interactions were notably higher, with 57% of the experimental group achieving a "high" level (more than four verbal exchanges) compared to 7% of the control group, also statistically significant

($t(26) = -2.31$, $p = 0.02$) (see Figure 5).

Observations indicated that AI-driven challenges promoted individual participation, collaborative problem-solving, and higher motivation and enjoyment. The analysis, conducted with 28 students, demonstrated significant effects of AI-enhanced activities on student performance and engagement. AI-based methods positively impacted task success and elements of engagement such as motivation and spontaneous participation. We believe that the success rate in the AI group can improve over time. Observations revealed that some students in the AI group initially displayed apprehension due to the novelty of AI-based activities. With continued practice, these activities are likely to yield better results. This perspective is strongly supported by the feedback gathered through an oral questionnaire conducted by the teachers overseeing the class.

These findings suggest that integrating AI into early education can foster deeper involvement and better conceptual understanding. Future research could further explore long-term benefits and scalability of AI-driven educational strategies.

AI-Enhanced STEM Framework: Advancing Evaluation and Self-Evaluation

The integration of Artificial Intelligence (AI) into Science, Technology, Engineering, and Mathematics (STEM) education offering innovative approaches to evaluation and self-evaluation. Traditional evaluation methods often rely on standardized testing, which may fail to capture the complexity of students' learning progress. AI-enhanced STEM frameworks, however, provide real-time, adaptive, and personalized assessment mechanisms that not only measure students' knowledge and skills but also foster their ability to self-evaluate and regulate their learning. This section explores how AI-powered STEM education enhances both evaluation and self-evaluation, promoting a deeper understanding of concepts, improving learning outcomes, and empowering students to take ownership of their academic growth.

The evaluation focused on both quantitative and qualitative metrics derived from the conducted experimentation, comparing the AI-integrated learning environment to traditional instructional methods. Through statistical analysis, observational assessments, and student engagement measures, this evaluation aims to determine whether AI-enhanced learning fosters better attention control, cognitive endurance, problem-solving abilities, and self-evaluation skills.

The study utilized a controlled experimental design, with a sample of 28 preschool students randomly divided into an experimental group (AI-enhanced learning activities) and a control group (traditional STEM learning). Evaluation was conducted through three primary methods: cognitive performance assessment, measuring task success rates, attention retention scores, problem-solving accuracy, and self-evaluation capability; behavioral observations, assessing student engagement levels, participation frequency, and peer interactions; and student and teacher feedback, collecting qualitative insights on motivation, learning experiences, perceived benefits of AI-driven learning, and auto-evaluation tendencies. The evaluation criteria were structured to capture both immediate and sustained cognitive effects, providing a comprehensive understanding of the impact of AI-enhanced STEM learning on attention skills and metacognitive awareness.

Quantitative findings showed significant improvement in task completion rates among students in the AI-enhanced learning group. The experimental group exhibited a 43% high-attention level compared to 29% in the control group. Additionally, problem-solving accuracy was notably higher, with AI-assisted students completing structured challenges more efficiently. Statistical significance was confirmed through a t-test ($t(26) = -3.44$, $p < 0.001$), indicating that AI-driven interventions positively influenced attention retention, task success, and self-evaluation capacities. Motivation levels were higher in the experimental group, with 57% of AI-assisted students displaying high engagement compared to only 7% in the control group. Engagement was measured by the frequency of voluntary participation, number of peer interactions, and observed enthusiasm during learning activities. The comparative analysis demonstrated that AI-driven challenges fostered higher student interaction, curiosity, and an increased ability to reflect on their own learning progress. AI tools allowed students to track their achievements, identify weak areas, and adjust their approaches accordingly, fostering self-assessment skills that are crucial for lifelong learning.

AI in Evaluation: A More Precise and Adaptive Approach

AI-driven evaluation systems offer significant improvements over conventional assessment methods by integrating adaptive learning technologies, data analytics, and intelligent feedback mechanisms. Unlike static tests, AI-powered platforms assess students dynamically, adjusting the difficulty of tasks based on their responses. This personalized approach allows for a more accurate measurement of students’ competencies, identifying strengths and areas that require further development.

Moreover, AI enhances evaluation by leveraging real-time analytics. Educators can access detailed reports on students’ progress, identifying patterns in learning behaviors and potential knowledge gaps. By analyzing vast datasets, AI algorithms can detect trends that human assessors might overlook, leading to more informed pedagogical decisions. For example, AI-powered platforms can track students’ problem-solving processes, offering insights into not just whether they arrived at the correct answer but also how they approached the problem. This allows for a more holistic evaluation of cognitive skills, creativity, and analytical thinking.

Additionally, AI-driven assessment tools reduce biases often associated with human grading. Automated grading systems ensure consistency and fairness by applying objective criteria uniformly across all students. Natural Language Processing (NLP) models can even evaluate written responses with a level of precision comparable to human graders, assessing factors such as coherence, argument structure, and depth of reasoning. As a result, AI facilitates a more comprehensive and equitable evaluation system that accurately reflects students’ learning progress.

AI-Enhanced Self-Evaluation: Empowering Students to Reflect and Improve

Beyond traditional evaluation, AI plays a crucial role in fostering self-evaluation, enabling students to monitor their own progress and refine their learning strategies. Self-evaluation is a fundamental skill that encourages metacognition, allowing students to assess their understanding, set learning goals, and take corrective measures when necessary. AI-powered STEM frameworks support self-evaluation in several ways:

Real-Time Feedback for Continuous Improvement

AI-enabled learning platforms provide immediate feedback, helping students recognize their mistakes and correct them in real-time. Unlike conventional assessments where feedback is often delayed, AI-powered tools offer instant insights, reinforcing learning while the material is still fresh. For instance, AI-driven coding platforms allow students to test their programs instantly, identifying errors and suggesting improvements, thereby fostering a more iterative and self-directed learning process.

Personalized Learning Paths

AI customizes learning experiences based on individual performance, allowing students to progress at their own pace. By analyzing students' strengths and weaknesses, AI-driven systems recommend tailored exercises, supplementary materials, and targeted problem-solving activities. This personalized approach encourages students to take charge of their learning, as they receive guidance that aligns with their unique needs and learning styles.

Data-Driven Self-Reflection Tools

AI-powered dashboards and progress trackers help students visualize their learning journey, offering insights into areas of improvement. These tools enable students to reflect on their achievements and set realistic academic goals. For example, students can review their performance trends over time, identify recurring challenges, and adjust their study strategies accordingly. This promotes a proactive mindset, where students engage in self-directed learning rather than relying solely on teacher intervention.

Gamification and Motivation

AI-enhanced STEM education often incorporates gamification elements that encourage self-evaluation through interactive challenges, badges, and progress milestones. These features increase engagement by making learning more enjoyable and rewarding. When students see their progress reflected through gamified elements, they are more likely to stay motivated and take an active role in evaluating their own learning.

The Impact on Educators and Pedagogical Strategies

The integration of AI into STEM education not only benefits students but also transforms the role of educators. AI-powered evaluation tools reduce the administrative burden of grading and assessment, allowing teachers to focus more on instructional design and personalized support. Instead of spending hours grading assignments, educators can use AI-generated insights to tailor their teaching approaches, providing targeted interventions for students who need additional support.

Furthermore, AI facilitates more formative assessment strategies, shifting the focus from high-stakes testing to ongoing learning development. Teachers can implement AI-driven quizzes, interactive problem-solving exercises, and simulated experiments that provide continuous feedback, fostering a more dynamic and student-centered learning environment. This approach aligns with modern educational philosophies that emphasize the importance of process-oriented learning rather than just outcome-based assessment.

Challenges and Ethical Considerations

While AI offers numerous advantages in evaluation and self-evaluation, several challenges must be addressed to ensure its effective implementation. One major concern is data privacy—AI-driven learning systems collect extensive data on students' performance, raising ethical questions about how this information is stored and used. Educational institutions must establish clear policies to protect students' privacy while leveraging AI for assessment.

Another challenge is ensuring accessibility and equity. Not all schools have the resources to implement AI-driven learning systems, which may widen the digital divide between students who have access to these technologies and those who do not. Policymakers and educators must work together to bridge this gap, ensuring that AI-enhanced STEM education remains inclusive and benefits all learners.

Additionally, AI should complement, rather than replace, human evaluation. While AI algorithms can provide valuable insights, human educators bring essential elements of empathy, contextual understanding, and critical judgment that technology cannot replicate. Therefore, a balanced approach that integrates AI-driven assessment with teacher-guided evaluation is crucial.

Conclusion

STEM education and AI-powered learning tools serve as powerful instruments for cultivating concentration and cognitive endurance (Luckin et al., 2016). By engaging in problem-solving, hands-on experimentation, and computational thinking, individuals strengthen their ability to focus for extended periods (Pea & Kurland, 1984). As the modern world continues to demand greater cognitive efficiency, fostering concentration through STEM disciplines and AI-enhanced learning remains a crucial factor in both personal and professional success (Gazzaley & Nobre, 2012). Encouraging STEM and AI engagement from an early age establishes a foundation for lifelong learning, adaptability, and intellectual resilience, equipping individuals with the focus and problem-solving skills necessary to thrive in an increasingly complex and fast-paced world (Shute et al., 2017).

Moreover, the AI-enhanced STEM framework represents a significant advancement in educational evaluation and self-evaluation. By providing real-time, personalized, and data-driven insights, AI empowers both students and educators to engage in more effective learning and assessment processes. Students develop stronger self-regulation skills, allowing them to identify weaknesses, set learning goals, and refine their strategies independently. Educators benefit from AI-driven analytics that inform instructional decisions, enabling them to offer more targeted support.

As AI continues to evolve, its integration into STEM education will redefine how evaluation and self-evaluation are conducted, fostering a more adaptive, equitable, and student-centered learning experience. While challenges remain, the potential benefits of AI-driven assessment far outweigh its limitations, making it an indispensable tool for shaping the future of education. By embracing AI-powered evaluation methods, educational institutions can cultivate a generation of learners who are not only knowledgeable but also equipped with the skills to self-assess, adapt, and thrive in an ever-changing world.

References

Moqbel, M., & Kock, N. (2018). *Unveiling the Dark Side of Social Networking Sites: Personal and Work-related Consequences of Social Networking Site Addiction*. Information & Management, 55(1), 109-119.

Junco, R., & Cotten, S. R. (2012). No A 4 U: *The Relationship Between Multitasking and Academic Performance*. Computers & Education, 59(2), 505-514.

Posner, M. I., & Rothbart, M. K. (2007). *Educating the Human Brain*. American Psychological Association.

Holiday, R. (2019). *Stillness Is the Key*. Portfolio.

Lachaux, J.-P. (2015). *Le Cerveau Attentif: Contrôle, Maîtrise et Lâcher-prise*. Odile Jacob.

Smallwood, J., & Schooler, J. W. (2015). *The Science of Mind Wandering: Empirically Navigating the Stream of Consciousness.* Annual Review of Psychology, 66, 487-518.

Kahneman, D. (1973). *Attention and Effort*. Prentice-Hall.

Ribot, T. (1889). *The Psychology of Attention*. Open Court Publishing Company.

James, W. (1890). *The Principles of Psychology*. Henry Holt and Company.

Van Zomeren, A. H., & Brouwer, W. H. (1994). *Clinical Neuropsychology of Attention*. Oxford University Press.

Cherry, E. C. (1953). *Some Experiments on the Recognition of Speech, with One and with Two Ears*. The Journal of the Acoustical Society of America, 25(5), 975-979.

Broadbent, D. E. (1958). *Perception and Communication*. Pergamon Press.

Chi, M. T. H., & Wylie, R. (2014). *The ICAP framework: Linking cognitive engagement to active learning outcomes*. Educational Psychologist, 49(4), 219-243.

Diamond, A. (2013). *Executive functions*. Annual Review of Psychology, 64, 135-168.

Gazzaley, A., & Nobre, A. C. (2012). *Top-down modulation: Bridging selective attention and working memory*. Trends in Cognitive Sciences, 16(2), 129-135.

Gazzaley, A., & Rosen, L. D. (2016). *The Distracted Mind: Ancient Brains in a High-Tech World*. MIT Press.

Klingberg, T. (2009). *The Overflowing Brain: Information Overload and the Limits of Working Memory*. Oxford University Press.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Education*. Pearson Education.

Mayer, R. E. (2004). *Should there be a three-strikes rule against pure discovery learning? The case for guided* *methods of instruction*. American Psychologist, 59(1), 14-19.

Pea, R. D., & Kurland, D. M. (1984). On the cognitive effects of learning computer programming. New Ideas in Psychology, 2(2), 137-168.

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). *Demystifying computational thinking*. Educational Research Review, 22, 142-158.

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Annex Example of Other activities

Activity Title	Time Traveler's Clock
Objective	Teach students to understand time, fractions, and arithmetic by helping a "time traveler" adjust their clock using addition and subtraction.
Materials Needed	• small Printable clock faces • Cardboard or paper cut-outs of hour and minute hands • Computers/tablets with a basic app or game that uses time-telling or clock operations
Steps	
1. Introduction to Clocks (10 min)	• Explain how to read both analog and digital clocks, emphasizing how to calculate time differences (e.g., from 2:00 to 3:00, or 3:15 to 3:45). • Use real-life examples of timekeeping (daily routines, school schedules).
2. Time Travel Challenge (20 min)	• Present a "time traveler" who needs to adjust their clock to the correct time. The students will be given a series of time-based challenges (e.g., "If it's 3:00 now, what time will it be in 45 minutes?"). • As students answer these questions, they manipulate their own clocks (either physical or digital) to find the correct times.
3. Time Travel with Technology (20 min)	• Use a simple app or game where students can interact with time-based problems. Many apps simulate a clock and time-based challenges where students need to calculate elapsed time. • Alternatively, use a machine learning tool to create a "time detection" model: students can upload images of clocks showing different times and train the model to recognize and tell time.
4. Discussion and Reflection (10-15 min)	• Discuss how understanding time is essential in math and everyday life. How do we use time in calculations, like adding or subtracting hours? • Ask the students how technology (like the apps or tools used in the activity) helps them solve problems faster.
Mathematical Concepts	• Time (analog and digital clocks) • Arithmetic (addition and subtraction of hours and minutes) • Fractions (e.g., half-past, quarter-to)

Table 2: This table outlines the objectives, required materials, and steps for the "Time Traveler's Clock" activity, which integrates concepts of time, arithmetic, and fractions in an engaging, problem-solving context.