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The relationship between arithmetic proficiency and artificial intelligence-assisted learning

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ABSTRACT

Amidst the rapid developments witnessed in educational environments, this study aims to investigate the dynamic relationship between the desire for artificial intelligence (AI) supported learning and proficiency in mental arithmetic, considering the latter a decisive factor in enhancing cognitive acquisition. The study focused specifically on the academic elite, represented by students in the mathematical sciences track at the qualifying secondary level. To ensure the accuracy of the results, the methodology relied focusing particularly on the arithmetic subtest within the Wechsler intelligence scale for children as an effective tool for measuring logical reasoning and working memory. The target sample consisted solely of adolescents, who were characterized by a similarity and a homogeneity in their developmental stages and ages. Selection and analysis criteria were based on two pillars, the general scores obtained in the arithmetic subtest, and a systematic evaluation of the students' aptitude and inclination toward using AI tools. The results concluded that there is a close correlation between arithmetic ability and the quality of logical reasoning in AI contexts. Furthermore, statistically significant homogeneity confirmed that students proficient in AI skills demonstrate higher levels of creative thinking and the ability to apply logic in learning.

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1. INTRODUCTION

Mathematics has always occupied a prestigious place in cognitive science, although it is often reported as a difficult subject to grasp [1], [2]. This perceived difficulty often stems from the intricate interplay of domain-specific numerical cognitive abilities and broader domain general cognitive processes such as executive function, working memory, and attention [3]. This complexity is particularly pronounced in arithmetic, where foundational numerical concepts intersect with executive functions to facilitate problem-solving and abstract reasoning. Given that mathematical skills are closely linked to working memory, visuospatial attention, and processing speed, a thorough understanding of these cognitive functions is paramount for effective pedagogical and interventional strategies [4].

Indeed, arithmetic and logical abilities are considered the absolute benchmark and the most accurate indicator for evaluating human intelligence and the quality of deductive reasoning. However, the contemporary educational landscape is experiencing a decisive adoption with the accelerated integration of artificial intelligence (AI) applications into classrooms, which is creating a cognitive divide and strong polarization within the academic community. This paradigm shift necessitates an examination of how such technological acculturation influences traditional measures of cognitive performance, particularly within specific cultural contexts where standardized assessments like the Wechsler intelligence scale for children may require adaptation [5]. Although the arithmetic operations are teaching begins in kindergarten, academic literature also indicates that students encounter challenges throughout their arithmetic learning journey [1], [2]. The effective using by students of digital tools can really help them by facilitate the learning process [6]. It enhances and contributes to improved academic performance through student interaction using digital tools [2], [7].

On the one hand, some warn against the risk of cognitive atrophy and the decline of students' genuine intellectual capabilities due to excessive reliance on ready-made algorithmic solutions; indeed, they argue that this threatens the autonomy of the human mind. On the other hand, others view this digital revolution as a promising pedagogical medium and a tool to strengthen the educational infrastructure. This allows learners to free themselves from routine tasks to focus on higher-order thinking skills and complex analysis. In this context, digital tools, such as mini-apps, contribute to increasing student engagement during mathematics classes. Thus, the mathematical content can be better understood by students through interaction with digital tools [2], [8], [9].

Advancements in educational technology have prompted math education researchers to identify two primary roles for digital tools the first as assisting teachers with administrative tasks like creating worksheets and grading, and the second as a providing innovative ways to practice and visualize mathematical ideas [10], [11]. Starting from this cognitive and pedagogical issue, and in order to decipher the complex relationship between the human mind and AI, the utility of digital tools as cognitive instruments stands out among the various methods of use [2], [6]. This research goes beyond the simple observation of technological usage rates; indeed, a technology evolves into a cognitive tool once it is applied to promote learning and the development of knowledge [2], [6].

In light of this debate, it becomes essential to understand the deep psychological mechanisms and intrinsic motivations that govern students interactions with these technologies, in order to determine whether they will act as a tool undermining intellectual skills or, conversely, as a genuine lever for development. Understanding this relationship directly informs educational policy, curriculum design, and classroom practice.

This field study aims to reveal the modern cognitive intersections between technology and intellectual capabilities. The specific objective aims to examine the interactive and correlational link between students' motivation to use AI for learning as a the independent variable and their degree of computational proficiency as athe dependent variable, serving as a measure of cognitive capability. It deeply explores the psychological structure of the learner, analyzing motivation as the behavioral driver that guides the use of technology, and computational excellence as the cognitive product reflecting the integrity of mental processes. Consequently, this study attempts to provide a scientific answer regarding the conditions and dynamics that transform AI from a mere tool for rapid problem-solving into a lever for intellectual emancipation and the development of computational excellence, relying on precise psychological measurement tools and rigorous statistical criteria to guarantee the credibility of the results.

Globally, this debate juxtaposes the risk of cognitive atrophy caused by an over-reliance on algorithmic solutions against the promise of freeing learners from routine tasks to focus on higher-order complex analysis. This dynamic is particularly vital to examine within the Moroccan public school system. Characterized structurally by a family environment that often offers limited support for formal educational pathways and reflects a modest socioeconomic status, the Moroccan context simultaneously experiences a high penetration of mobile technological tools. Therefore, situating this research within Moroccan educational priorities allows us to investigate whether digital mobility and AI can transcend socio-economic barriers and serve as a genuine equalizer for cognitive acquisition and mathematical education.

2. METHOD

2.1. Participants

The study utilized purposive sampling to focus specifically on the academic elite, represented by students enrolled in the mathematical sciences track at the qualifying secondary level. The final target cohort consisted of 130 adolescents, evenly split by gender. A primary methodological strength of this group lies in its significant homogeneity, regarding both neurocognitive development and chronological maturity. The group presents a mean age of 16 years, 1 month, and 12 days, placing the study at the heart of the pivotal late adolescence period. The group's consistency is confirmed by a particularly narrow standard deviation of only 1 month and 6 days. This low temporal variability limits potential biases related to developmental stage differences. It ensures that the collected observations are representative of a specific and stable growth plateau, thereby enhancing the reliability of the statistical comparisons performed within the cohort.

2.2. Materials

The assessment phase of this study was based on a multidimensional approach, combining contextual questionnaires and standardized psychometric tests. A specific questionnaire was administered to participants to document their family sociocultural environment, identify any sensory impairments (visual or auditory), and measure their degree of technological acculturation, particularly their experience with AI. Global cognitive assessment was conducted using the Wechsler cognitive intelligence scale for children and adolescents (WISC), selected for its reliability and clinical recognition in measuring intellectual abilities in minors. To ensure optimal concentration conditions and minimize stress, the test was administered in individual sessions organized during the students' free time. Although distinct from the full scale intelligence quotient (IQ), the “Arithmetic” subtest was specifically utilized. This subtest consists of 34 items, comprising a series of mathematical problems presented through pictorial or verbal items, which the adolescent must solve mentally. Integrated into the Fluid Reasoning Index (or working memory index, depending on the version/model used), this test allowed for the precise quantification of logical reasoning abilities and working memory performance. The entire administration process and score processing were done exactly conducted in strict accordance with interpretation manual the technical guidelines stipulated in the official Wechsler administration and scoring manual [12], [13].

2.3. Data collection and analysis

The data collected processing phase was optimized through the use of advanced and important digital tools, ensuring maximum precision of results. Once the WISC was administered, raw data were transmitted via the Q-global online platform [13]. This reliance on automated scoring eliminated the risk of calculation errors inherent in manual conversion while significantly accelerating the processing workflow. Final results were consolidated into standardized and composite scores, providing a rigorous overview of the participants' cognitive abilities. For data analysis, the most recent version of SPSS software was utilized. This tool was employed to verify measurement reliability, produce descriptive statistical analyses (means and standard deviations), and perform t-tests to compare the means and see if there are any differences in the sample that are statistically significant.

2.4. Socioeconomic status and educational level

This research is situated within the context of the Moroccan public school system, an environment characterized by a certain social uniformity due to the scarcity of students from privileged backgrounds. This context is often marked by a family environment that, structurally, offers limited support for formal educational pathways. A particularly low level of parental education is observed, reflecting modest socioeconomic status and limiting traditional academic support resources within the home. In contrast to this low academic capital, the study reveals high penetration of technological tools. A notable proportion of participants have access to a computer or a mobile phone at home. This phenomenon is reinforced by the fact that nearly all family members own a smartphone with permanent internet access, indicating that the digital divide is less a matter of material access than of educational application.

3. RESULTS

As visually represented in Figure 1, the first graph illustrates the distribution of students relative to the theoretical mean for overall performance on the arithmetic subtest. There were 89% of the students achieved results above the mean, while 11% presented results below the mean. The average score obtained by the entire sample stands at 14.25 out of 20.

As illustrated in Figure 2, the second graph analyses the intellectual positioning of the participants relative to the theoretical IQ norm. A large majority, representing 92% of the sample, possesses an IQ above the mean; only 8% of the sample falls below the mean, with a standard deviation representing half of the theoretical mean. Furthermore, girls and boys achieved equivalent scores. Reliability, measured by Cronbach’s alpha coefficient, is 0.860.

As shown in Figure 3, the third graph details sensory health in terms of the prevalence of visual and auditory impairments within the group. Approximately 76% of the students present no sensory issues, representing the vast majority of students suffering from neither visual nor auditory impairments. Nearly one-fifth of the students 19% experience vision problems. A small percentage of students (4%) presents a hearing impairment. The co-occurrence of impairments (visual and auditory) is extremely rare, affecting less than 1% of the sample.

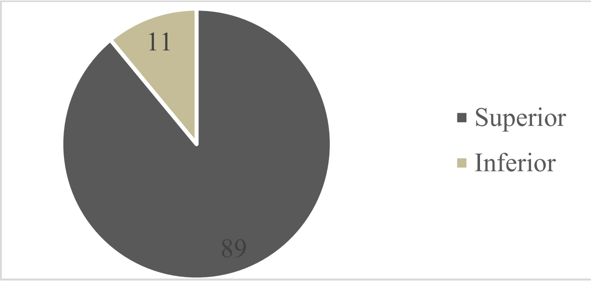

Figure 1. Distribution of students relative to the theoretical mean in overall arithmetic subtest performance

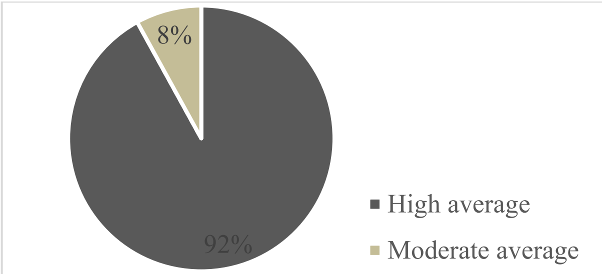

Figure 2. Distribution of students according to their IQ level

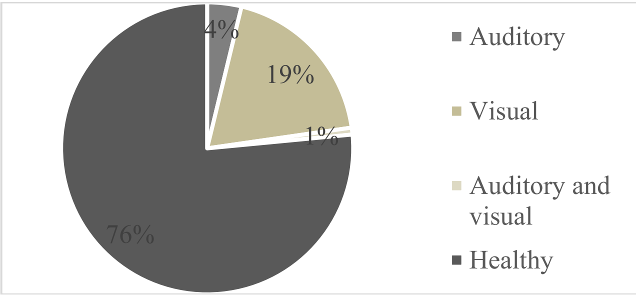

Figure 3. Prevalence of sensory impairments within the study sample

Gender-based analysis reveals a slight disparity regarding visual health: 10% of girls are affected by an impairment, compared to 9% of boys. The prevalence of auditory disorders remains low, standing at 2% for each gender within the sample. Finally, a single case of dual impairment (visual and auditory) was recorded in one female student.

Table 1 measures the relationship between eight factors and the arithmetic subtest using the Pearson correlation coefficient r and statistical significance p. All factors present a $p<0.05$. Therefore, the results are not due to chance and are all statistically significant. All r values are positive $r>0$, indicating that each factor evolves in the same direction as the studied variable. The correlations range from 0.182 (weak) to 0.660 (strong).

Table 1. Correlations between techno-educational factors and arithmetic performance

Factor	r	p
Interest in AI-mediated learning.	0.660	0.000
Utilization of AI in daily practices.	0.509	0.000
Availability of at least one mobile phone in the household.	0.453	0.000
Availability of computer equipment within the family unit.	0.395	0.000
Internet accessibility.	0.266	0.002
Socioeconomic status (income).	0.182	0.038
Family educational capital.	0.215	0.014
Preschool attendance rate.	0.308	0.000

AI-related factors show that direct engagement with AI is the most powerful predictor. Interest in AI-mediated learning r=0.660 has the highest score in the table, suggesting that motivation and personal interest are the primary drivers. For the exploitation of AI in daily practices r=0.509, concrete use follows interest. There is a strong correlation between the practical application of AI and the performance variable.

Factors related to hardware access and education play an important role but are less determinant than the attitude toward AI. The availability of a mobile phone r=0.453 is more strongly correlated with the variable than owning a computer r=0.395. This highlights the importance of digital mobility. The availability of computer equipment r=0.395 remains a solid supporting factor. The preschool attendance rate r=0.308 has a moderate and consistent impact on future results.

Although significant, environmental and socioeconomic factors these structural elements have the weakest link to the studied variable. Surprisingly, Internet accessibility r=0.266 is less influential than the possession of the device itself. Family educational capital r=0.215 has a positive but limited influence. However, the correlation for socioeconomic status/income r=0.182 is the weakest and least significant p=0.038. Household income is the least predictive factor in this study.

4. DISCUSSION

The in-depth analysis of the data collected during this study highlights particularly positive, rich, and illuminating results for understanding the dynamics between students' cognitive abilities (as measured by the arithmetic subtest), their socioeconomic environment, and their interaction with AI. Initially, the specific assessment of the arithmetic subtest reveals an overall highly satisfactory level of aptitude. Indeed, the average score obtained by all participants was strong, demonstrating a solid initial mastery of the quantitative and logico-mathematical concepts evaluated in this domain. This favorable trend is largely confirmed when observing overall performance on the arithmetic subtest. A vast majority of the cohort a large percentage of the students managed to achieve results above the theoretical reference mean set at 10. Conversely, only a minority of the sample falls at the average of this academic requirement threshold. This indicates a generally high level of mathematical reasoning ability within the cohort, which may favorably impact their engagement with AI-mediated learning [14].

In parallel with these strictly academic skills, the evaluation of the participants' IQ illustrates a highly similar cognitive dynamic. The results indicate that several students present a score above the standard theoretical average of 100, thus highlighting a particularly high general intellectual profile within this group. Conversely, the proportion of students displaying an IQ close to the theoretical reference average is marginal, representing only one-tenth of the sample, The same values appeared in previous studies in both urban and rural areas [15], [16]. In fact, several studies showing similar results to those obtained in the present study for IQ and arithmetic tests utilized samples originating from family backgrounds characterized by high income and educational levels [17], [18]. The results indicate that adolescents are influenced by culture and linguistic skills; they also demonstrate superior abilities in mentally manipulating numerical reasoning skills, intellectual alertness, short- and long-term memory, working memory, concentration and attention [19]–[22].

Overall, the convergence of these statistics suggests excellent dispositions for mathematical reasoning, correlated with cognitive abilities generally above the norm. Therefore, the study clearly focuses on a population endowed with highly developed fluid reasoning capabilities. This robust intellectual profile, characterized by strong fluid intelligence and arithmetic proficiency, suggests that the cohort possesses a heightened capacity for abstract thinking and problem-solving, which are critical for engaging with complex computational concepts [23]. This inherent aptitude for logical deduction and pattern recognition positions them well for understanding and interacting with AI systems, as evidenced by studies indicating a strong correlation between mathematical intelligence and the ability to identify logical connections [24].

Learning environments that let people learn in their way try new things and learn from their mistakes can really help people get the most out of mindset interventions. These environments allow people to look at math problems from angles and get really involved in learning, which goes beyond just the usual math lessons [25], [26]. Furthermore, the good thing, about these learning environments is that people get better at math because they really understand the concepts, not just because they can do the problems faster. They start to see how all the different math ideas are connected, which helps them learn more [26]–[28].

The analysis of the studied cohort, based on the total student population, reveals a particularly reassuring overall trend regarding the participants sensory health. An overwhelming majority of the group presents no visual or auditory anomalies. This high proportion of students free from any impairment constitutes a major statistical finding of this census. Nevertheless, the remaining fraction of the population are also important and they need our special attention. Among students facing sensory challenges, a very marked disparity is observed between the two types of impairments. The data clearly indicate that visual impairments are the dominant concern and are by far the most frequent within this subgroup. Auditory impairments, in comparison, prove to be much less prevalent.

Finally, it is important to highlight the very low prevalence of comorbidity within this sample. The conjunction of both impairments in a single individual is an entirely exceptional situation: only one single case of a student cumulating both visual and auditory difficulties was identified. This highly isolated nature confirms that while sensory impairments affect a specific portion of the students, their overlap remains a strictly marginal phenomenon. Furthermore, the absence of gender bias and the rarity of physiological obstacles guarantee that the observed performance variations are genuinely linked to the evaluated environmental and behavioral factors, rather than to intrinsic learning barriers.

The focal point of this research lies in the correlation analysis. The results dramatically settle the debate concerning arithmetic success and technology use. Interest in AI-mediated learning is the most powerful predictive factor for success in arithmetic. This demonstrates that intellectual curiosity toward technology stimulates logical capabilities, contradicting the hypothesis of cognitive atrophy.

A study in Sweden looked at using tools in math classes. It involved 68 students aged 17 to 18 and three teachers from schools. The teachers were told to use the tool in any way they thought was best, for their teaching. The results showed that teachers did not keep an eye on students while they used the tool. This suggests that teachers need help on how to use these tools in their classes with digital artifacts [29]. When we want to use things to help students learn the teacher needs to pick the best digital thing and make sure students use it in a way that makes sense. The teacher has to help students use these things in a structured way so they can really learn from them [30].

The daily use of AI ranks second. The digital tool, when utilized by already logical minds (as evidenced by the group's high IQ), acts as an amplifier of intelligence and creative thinking rather than simply a cheating tool or the easy way out. Using things like artifacts is not enough to make people learn [6], [29]. To ensure student learning, it is imperative that teachers monitor the process [31].

The study highlights a fascinating nuance regarding technological hardware: owning a mobile phone proves to be more decisive than owning a computer. This suggests that the mobility, spontaneity, and familiarity of the smartphone interface align better with modern adolescent learning habits. AI, accessed via the smartphone (the quintessential tool for digital mobility), appears to function as an equalizer of opportunities. By offering immediate access to complex problem-solving methods, it allows the motivated student to overcome the limited cultural or economic capital of their household.

Counterintuitively, mere access to the internet has a lesser impact than the ownership of the device itself. This implies that a student benefits more from the personal appropriation of a tool (being able to use offline applications, calculation tools, or structure their own digital environment) than from a simple passive connection to the network. AI as a great socioeconomic equalizer is perhaps the strongest sociological conclusion of these results; social determinism seems to fade in the face of technological engagement. Family educational capital, and especially socioeconomic status, are the factors that least influence arithmetic performance. In a context where parents may lack the academic resources to assist their children (low family educational capital), AI compensates for this gap by acting as a personalized tutor. AI thus transcends socioeconomic barriers, enabling motivated students, even those from modest backgrounds, to achieve cognitive excellence.

Although technology is central, the physiological and educational foundations must not be overlooked. The prevalence of visual impairments serves as a reminder that intensive screen use requires ophthalmological monitoring so as not to hinder learning. Additionally, the moderate impact of preschool confirms that cognitive structures are formed early, creating the fertile ground upon which AI can subsequently act.

In summary, these results prove that a student's mental efficiency in the digital age depends less on their parents financial resources than on their own motivation to use AI as a lever for intellectual development. The study focused specifically on the academic elite, represented by students in the mathematical sciences track. Because of this purposive sample, the findings may not be universally generalizable to students with diverse initial learning obstacles or lower baseline cognitive markers. Furthermore, as a cross-sectional study, we captured a specific developmental plateau (late adolescence). Future research should prioritize longitudinal studies to observe how the dynamic relationship between AI utilization and arithmetic proficiency evolves over longer academic lifespans. Additionally, experimental designs utilizing controlled AI-assisted interventions could further isolate causality, pinpointing exactly which digital pedagogical frameworks best accelerate computational excellence across varied socio-economic demographics.

5. CONCLUSION

This empirical study provides a nuanced and decidedly optimistic perspective on the integration of AI into mathematics education. The data compellingly demonstrate that the use of AI does not induce the "cognitive decline" feared by certain academic circles, at least within a demographic characterized by strong logical reasoning capabilities. Conversely, a strong positive correlation exists between the motivation to utilize AI and computational excellence. The primary significance of this research lies in demonstrating that psychological engagement and personal interest in AI transcend traditional social determinism. In a context of modest educational and economic capital, proficiency with mobile digital tools emerges as a genuine equalizer of opportunities, propelling adolescent cognitive development. Consequently, contemporary educational policies should move beyond mere technological provisioning and focus on pedagogical engineering specifically, how to transform students technological curiosity into structured, intrinsic motivation. Thus, AI establishes itself not as a substitute for human intellect, but as the cognitive extension of a mind inherently seeking meaning and logic.

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AUTHOR CONTRIBUTIONS STATEMENT

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Fatima Zahra Soubhi			✓			✓	✓		✓		✓			
Bouzekri Touri	✓				✓		✓			✓	✓	✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. No external affiliations or private sector partnerships played a role in the study's design, execution, or conclusions. All authors have reviewed the final manuscript and agree with this declaration of transparency.

ETHICAL APPROVAL

The research related to human use has complied with all the relevant national regulations and institutional policies in accordance with the strict tenets of the Helsinki Declaration. Furthermore, the study protocol was formally reviewed and approved by the authors' institutional review board prior to any data collection. Informed consent was properly obtained from all participants and their legal guardians, ensuring full ethical compliance.

DATA AVAILABILITY

All data utilized in this research are transparently presented within the article through tables, figures, and detailed discussions. The raw datasets generated and analyzed during the current study are not publicly available due to strict participant privacy protections. However, anonymized data extracts can be made available by the corresponding author, [KM], upon reasonable academic request.

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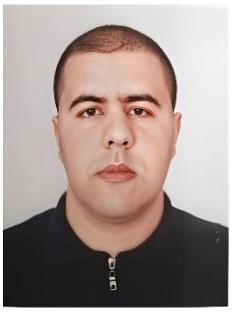

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