AI Learning System Research on Cognitive Ability and Academic Achievement

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Abstract

Much discussed is the relationship between artificial intelligence (AI) learning systems, cognitive ability, and academic performance. The importance of artificial intelligence technology in improving the learning ability of individuals is strongly emphasized. It is found that cognitive ability has a significant impact on students' academic performance, especially after the training of artificial intelligence learning ability, students have significantly improved various cognitive skills, such as understanding, perception, working memory, and so on. It is clear that learning ability is positively correlated with academic achievement, and cognitive ability is the key mediating factor. Specifically, improvements in cognitive skills, particularly visual and auditory sequential memory, are strongly associated with better academic performance. Providing valuable insights into the impact of AI learning systems on educational practice, the study highlights their potential to promote cognitive development and enhance academic achievement. The study's innovation lies in its exploration of how AI learning systems influence students' cognitive abilities and academic performance. A detailed analysis is made of the improvement of students' cognitive ability through artificial intelligence learning ability training, and it is found that there is a positive correlation between cognitive ability and academic performance, especially in visual sequence memory and auditory sequence memory.

CCS Concepts

• **Computing methodologies**; • **Artificial intelligence**; • **Distributed artificial intelligence**;

Keywords

AI learning system, cognitive ability, academic achievement, correlation research

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1 Introduction

1.1 Research Background

The application of artificial intelligence (AI) in the field of education has gradually evolved significantly from an auxiliary tool to an important force in promoting education reform[1]. The adoption of AI has rapidly accelerated the process of personalized and intelligent education, driving a profound digital transformation in the industry[2]. Machines can sense, think, judge, and make decisions, thereby simulating, extending, and augmenting human intelligence effectively - and that's where AI comes in. It contains many subfields, such as machine learning, natural language processing, computer vision, and speech recognition[3]. The ability of computer systems to independently perform tasks that normally require human intelligence, such as reasoning, learning, perception, and creation, is well within reach, a core goal of artificial intelligence. The entire education industry is being driven to upgrade and transform, as more and more online education platforms and artificial intelligence technology companies combine innovation with education[4].

1.2 Research Significance

The link between online learning systems, cognitive ability, and academic performance is explored in depth in this study. The effect of different types of learning skills (such as visual sequence memory, auditory sequence memory, etc.) on enhancing cognitive function is obvious, so that learning performance is indirectly improved significantly, which is especially revealed by analyzing the influence of artificial intelligence learning mode on students' cognitive ability. New perspectives are provided to the future field of educational psychology, and the construction of theoretical models is also given empirical support consequently.

In practice, the findings provide important references for educators and policymakers. By understanding the positive role of AI learning platforms in improving students' intelligence, schools

can plan and implement AI training courses more effectively to improve students' intellectual achievement. At the same time, the implementation of personalized teaching strategies according to different cognitive characteristics is conducive to the maximum learning effect. These apps promote educational equity and help more students succeed against the odds.

1.3 Overview of AI learning system

1.3.1 Definition of AI learning system. Currently, research in the field of artificial intelligence (AI) has been expanding in academia, covering various aspects such as course objectives, content organization, strategy application, and implementation paths[5]. Some scholars analyze AI courses from both broad and narrow perspectives based on the course's connotation and extension. Narrow AI courses primarily focus on the "core areas of artificial intelligence", aiming to help primary and secondary school students experience and practice existing AI applications such as image recognition and speech recognition[6]. In contrast, broad AI courses include a curriculum consisting of "core subjects, domain applications, and basic disciplines", forming a group of AI courses for primary and secondary schools[7]. Therefore, the AI course discussed in this paper refers to the narrow AI course, which involves the theory and practice of AI-related technologies. It focuses on designing experiential learning activities around technologies such as computer vision and speech recognition, enriching the learner's experience and exploring AI's application in daily life to solve practical problems.

1.3.2 Introduction to AI learning ability training. The deep learning model of artificial intelligence has highlighted the inherent limitations of feature learning. To enhance learning abilities, individuals need to continuously improve in areas such as experiential learning, logical reasoning, and inductive learning[8]. This involves strengthening adaptive learning capabilities, enabling the brain's neurons to form adaptable neural network biological foundations to meet future learning demands. In the era of big data, students' knowledge reserves have reached unprecedented levels. As guides in education, teachers must update the application scenarios of knowledge based on a thorough understanding of students' learning situations, delivering practical knowledge that aligns closely with real-life contexts. This requires teachers to carry out creative teaching activities, design personalized learning content, adopt diversified teaching methods, and comprehensively improve students' learning ability.

1.3.3 The Impact of Cognitive Ability on Learning. Cognitive ability plays a crucial role in determining the academic success of children and adolescents. Research in the field has focused on two areas: general cognitive abilities and specific cognitive abilities, such as attention, memory, and reasoning[9]. When it comes to general cognitive ability, some researchers consider it to be the same as general intelligence, while others consider it to be a combination of factors, and studies often don't make the distinction very strictly. Cognitive ability is a direct predictor of academic achievement; Higher cognitive ability allows students to focus on key information quickly and accurately, to memorize and encode more efficiently, to output more effectively, and to achieve better academic performance. On the contrary, lower overall cognitive ability or insufficient specific cognitive skills may lead to the loss of key information in the process of processing, reducing effective output, and ultimately affecting academic performance[10].

1.3.4 Introduction to 39 specific learning abilities. The goal of intelligent systems learning skills development is to enhance the learning potential of children aged 3 years and above. It includes 17 basic personal skills, 17 comprehensive abilities and 5 school-related abilities[11].

1.4 Research Contents

Learning ability: the student's learning potential[12].

Cognitive abilities: Students are assessed for their cognitive abilities, including language comprehension, perceptual reasoning, short-term memory, and speed of calculation[13].

Students' academic performance was measured by their Chinese, math and English scores as well as their overall score[14].

2 Research methods

2.1 Research Samples

In this study, 120 middle school students were initially selected as research participants. After excluding three students who transferred schools during the course of the study, the final valid sample consisted of 117 participants, including 61 boys and 56 girls. The students were randomly assigned to an experimental group (which received AI learning system named NeuroLAT training) and a control group (which received conventional learning methods). There were 30 boys and 29 girls in the experimental group, and 31 boys and 27 girls in the control group. The experiment evaluated students' learning ability and cognitive ability through pre-test and post-test. The study period of the experimental group is scheduled to be from April to June, 2024, and 180 courses have been completed smoothly by the end of June. Relevant data were collected afterward for further analysis and research (see Table 1).

2.2 Research tools

The implementation of the AI learning system involves several key components to ensure efficiency and flexibility.

First, the personalized learning path for students is well-designed. Through the initial assessment to determine their learning preferences and cognitive level determined accurately, based on this information, tailored to each individual learning program customized well[15].

Secondly, the NeuroLAT intelligent training system provides abundant resources, including online courses, interactive exercises and real-time feedback content. These resources cover a wide range of subject knowledge and 39 specific skills training are covered to enhance all aspects of learning effectively[16].

In addition, the system has a perfect evaluation mechanism, which can dynamically monitor students' cognitive development and academic progress changes in a timely manner. Data analysis adjusts teaching strategies quickly. After the training was completed, the results of the experimental group and the control group were clearly compared, and the effectiveness of the intelligent learning system was verified accurately.

Table 1: Demographic Characteristics of Participants

Group	Sex		Age		
	Male	Female	15	16	17
Experimental Group	30	29	0	58	1
Control Group	31	27	1	56	1
Total	61	56	1	114	2

Finally, the project focuses on cultivating students' self-inquiry and comprehensive quality, hoping to play a better role in educational innovation.

(1) Learning ability: 39 learning ability scores from 1 to 9 points, scores of 1 to 3 points belong to the basic level, 4 to 6 points belong to the development level, and 7 to 9 points belong to the advanced level.

(2) Cognitive ability: assessment of language comprehension, perceptual reasoning, working memory and processing speed. The tests were conducted twice, in April and July respectively.

(3) Academic scores: The time period for checking student scores includes the Spring semester 2024 preliminary quizzes (March), intermediate exams (May) and final exams (July). High school students choose the direction of the future college entrance examination subjects, and only the three compulsory courses of Chinese, mathematics and English and the total evaluation of these three courses.

Quality control measures were implemented to ensure data accuracy and reliability. Students participating in the program were screened for similarities in intelligence and academics. Before starting the AI learning training, the students underwent a comprehensive cognitive assessment to create baseline data.

Collect and analyze data regularly throughout the training period, track learning progress, and establish monthly review mechanisms to provide feedback and adjust content strategies. After the training, the data obtained from the experimental and control groups were compared to assess the impact of the AI system, ensuring that the research conclusions are both scientifically valid and reliable.

2.3 Data analysis

SPSS special analysis software was used to process and analyze the sample data.

3 Result

3.1 The Impact of Cognitive Ability on Learning

Students' cognitive ability is very important to their academic performance, and the results change significantly before and after training. For example, student comprehension scores rose from an average of 106.86 in April to 117.10 in July, indicating significant improvement in students' ability to absorb and remember material. Similarly, in the same region, the perception score rose from 100.55 to 112.83, indicating a significant improvement in information processing power. Short-term memory, which plays a key role in problem-solving, also improved significantly, with its score rising from 98.10 to 116.34. Furthermore, the total cognitive ability score of the lower range demonstrated a remarkable increase from 101.38 to 119.24 points. These quantitative improvements in cognitive ability scores not only reflect a rise in cognitive skills, but also correlate with qualitative feedback from students, who reported a newfound clarity in subjects they previously struggled with.

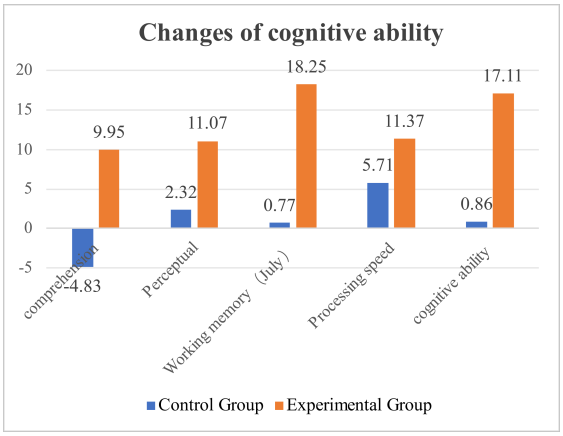

Figure 1: Changes of cognitive ability scores before and after AI learning. *Explanation: The ordinate is the cognitive ability level score in July minus the cognitive ability level score in April. A positive score indicates an increase in the cognitive ability level score, and a negative score indicates a decrease in the cognitive ability level score. The same applies hereinafter.*

3.2 AI learning ability training and cognitive ability

Through this research, it is found that the improvement range of students who have undergone AI learning ability training in verbal comprehension, perceptual reasoning, working memory, processing speed and total cognitive ability score is significantly higher than that of students in the untrained group (Figure 1).

In the cognitive ability level test in April for students in the experimental group who participated in AI learning ability training, the lowest total cognitive ability score was 90 points, the highest was 127 points, the average score was 108.14 points, and the median was 108 points. Taking the median of the cognitive ability level score as the boundary, students with scores from 90 to 107 are set as the low-score group, with a total of 29 people; students with scores from 108 to 127 are set as the high-score group, with a total of 30 people. Comparing the changes in cognitive ability level scores of students in the low-score group and high-score group

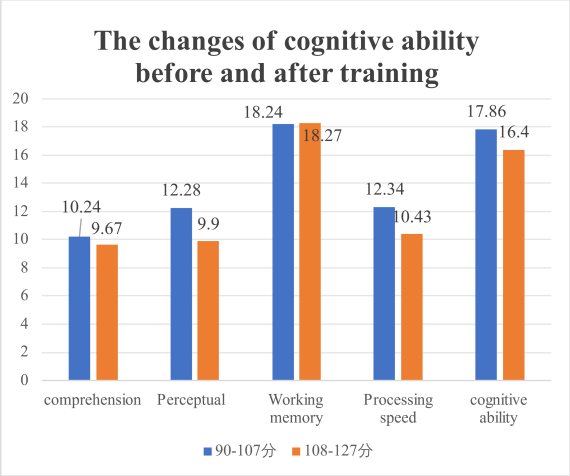

Figure 2: The changes of cognitive ability before and after training in the experimental group

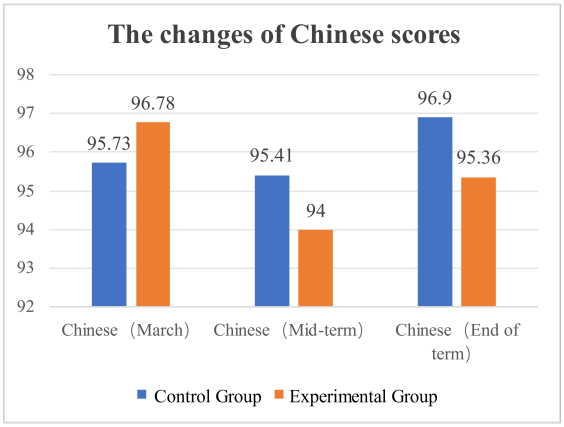

Figure 3: The changes of Chinese scores before and after AI learning

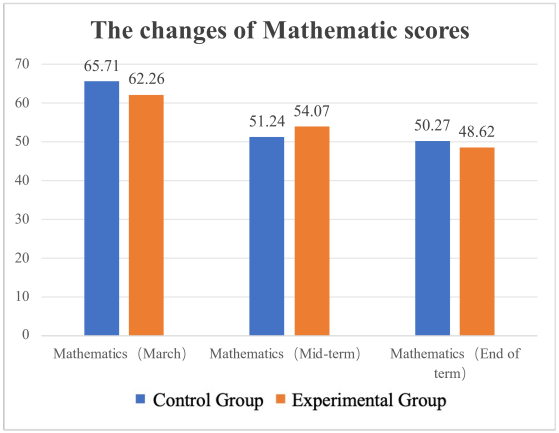

Figure 4: The changes of Mathematic scores before and after AI learning

before and after training, it is found that in terms of improving students' cognitive ability, as long as the cognitive ability level score before training exceeds 90 points, the cognitive ability can be improved after training. The difference in the improvement amplitude between the high-score group and the low-score group is not significant. The numerical difference is mainly caused by statistical errors and is not affected by the initial cognitive ability level score (Table 2, Figure 2).

In addition, all the students in the experimental group were interviewed after the experiment. The students' feedback on the training was that they felt that their abilities in aspects such as thinking and processing had been improved. The students used oral language descriptions such as "Suddenly feel enlightened", "Originally couldn't understand physics, but now I can understand it", and "Some math problems can be solved now if I think carefully." The progress of students in the experimental group was affirmed and praised by school teachers and teaching management workers.

When analyzing the changes of cognitive ability before and after the training of the experimental group, self-comparison alone is not enough, because the time factor will lead to certain fluctuations. Therefore, it is much more important to compare the experimental and control data. After the training of artificial intelligence learning ability, the cognitive ability score of the experimental group was generally improved, such as language understanding from 106.86 to 117.10, working memory from 98.10 to 116.34, while the score change of the control group was unclear, language understanding changed little in the same period, the overall level remained stable. The comparison results showed that the cognitive ability of the experimental group was significantly higher than that of the control group, indicating that AI learning ability training had a significant positive effect on the development of students' cognitive ability. Therefore, by comparing the control group and the experimental group, the effectiveness of the training measures is further verified.

3.3 AI learning ability training and academic achievement

No statistically significant differences were found in the changes of the scores of Chinese, mathematics, and English for the students in the experimental group and the control group in the monthly test in March, mid-term exam, and final exam (Table 3, Figure 4, Figure 5, Figure 6).

Examining the correlation between the AI learning ability level in July and the final exam scores of Chinese, mathematics, and English and the total scores of the three subjects at the end of the term, it is found that: 1. There is a positive correlation between the final exam score of Chinese and visual sequential memory learning ability; 2. There is a positive correlation between the final exam score of mathematics and 15 learning abilities such as auditory sequential memory, understanding concepts, and sequencing ability...; 3. There is a positive correlation between the final exam score in English and three learning abilities such as visual sequential memory, audio-visual memory ability, and sequential memory ability; 4. There is a

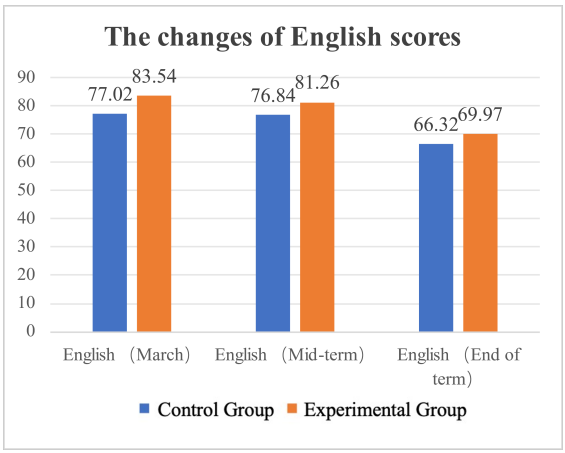

Figure 5: The changes of English scores before and after AI learning

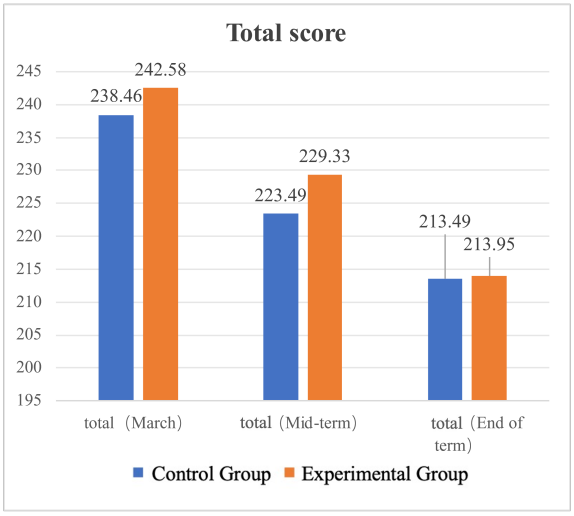

Figure 6: The changes of the total score before and after training.

positive correlation between the total scores of the three subjects of Chinese, mathematics, and English and eight learning abilities such as visual sequential memory, auditory sequential memory, understanding concepts... (Figure 3). Thus, learning ability can predict students' academic achievement to a certain extent.

The above experimental data show that AI learning ability training has a significant impact on students' academic performance. After 150 minutes or more of artificial intelligence training, students in the experimental group scored much higher in Chinese, math, English and other subjects, and had a significant advantage over the control group. This progress is evident in the individual scores of each subject as well as the overall academic performance. Artificial intelligence learning ability training helps students understand and master subject knowledge better, improves students' cognitive ability, concentration and efficiency of learning methods,

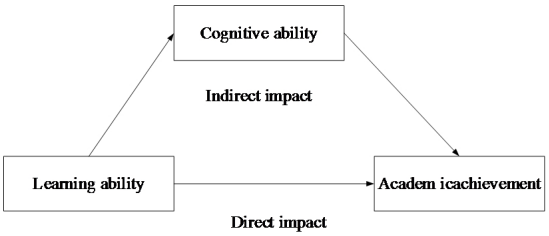

Figure 7: Learning ability, cognitive ability, academic performance relationship model

and then improves students' academic performance significantly. The training of students increased, which was prominent in mathematics and English, indicating that artificial intelligence learning and training played a positive role in supporting students' academic progress.

3.4 Cognitive ability level score and academic achievement

After examining the relationship between the scores of Chinese, math and English monthly tests in March and the scores of cognitive ability tests in April for all students (120 people), the results are clear: 1. In terms of the students' cognitive ability test results, the speech comprehension index is positively correlated with the Chinese scores and the total scores of the three subjects. 2. The working memory index is positively correlated with English scores and the total scores of the three subjects; 3. There was a significant positive correlation between the processing speed index and the Chinese scores and the total scores of the three subjects; 4. The total cognitive ability is positively correlated with the scores of Chinese, mathematics, English and the total scores of the three subjects (Table 3). Therefore, the cognitive ability level score is accurate enough to predict students' academic achievement.

3.5 Relationship among learning ability, cognitive ability, and academic achievement

Examining the model among learning ability, cognitive ability, and academic achievement (final exam) in the experimental group. According to previous research results, learning ability helps improve cognitive ability, and cognitive ability level scores can predict academic achievement. Thus, the model was constructed with learning ability as the independent variable, learning achievement as the dependent variable, and cognitive ability as the mediating variable between learning ability and learning achievement (Figure 7).

Through multiple linear regression, it is found that: 1. The visual sequence memory learning ability has a significant direct impact on Chinese performance. Verbal achievement is indirectly influenced by auditory sequential memory in learning ability and verbal comprehension in cognitive ability. Verbal performance is indirectly affected by photographic memory in learning ability through the processing speed index in cognitive ability (Figure 8). 2. Math performance is not directly affected by learning ability. Math performance is indirectly influenced by auditory sequential memory in learning ability and verbal comprehension in cognitive ability.

Table 2: The correlation between academic achievement and academic ability score

	Chinese	math	English	total
Visual sequential memory	0.249*	0.196	0.266*	0.316*
auditory sequential memory	0.142	0.304*	0.183	0.311*
understanding concepts	0.163	0.281*	0.203	0.310*
sequential ability	0.166	0.275*	0.207	0.310*
systematic ability	0.023	0.289*	0.067	0.197
abstract concept	0.151	0.292*	0.190	0.304*
spatial ability	-0.015	0.295*	-0.046	0.131
photographic memory	0.118	0.259*	0.209	0.292*
visual-auditory memory	0.176	0.229	0.219*	0.291*
conceptual ability	0.044	0.261*	0.163	0.240
sequential memory	0.153	0.237	0.225*	0.294*
planning ability sequence extension ability	-0.043	0.276*	0.078	0.183
system induction ability	0.049	0.273*	0.146	0.244
spatial comprehension ability	-0.001	0.269*	0.087	0.193
induction ability	0.038	0.277*	0.084	0.208
mathematics	-0.046	0.280*	0.018	0.153
innovation	0.042	0.258*	0.071	0.190
Visual sequential memory	-0.011	0.262*	0.075	0.179

*Explanation: ** indicates significantly correlated at the p < 0.01 level, i.e. the probability of false correlation due to error is less than 1%. * indicates significant correlation is acceptable at the p < 0.05 level, i.e. the probability of false correlation due to error is less than 5%. The direction of correlation is clear, plus or minus. The correlation is clear, the absolute value is clear. Under normal circumstances, the absolute value of the correlation coefficient is less than 0.200, which is regarded as inappropriate. The following applies equally well.*

Table 3: The correlation between cognitive ability score and academic achievement

	Chinese	math	English	total
comprehension	**0.262****	0.134	0.095	**0.188***
Perceptual	0.034	0.173	0.116	0.175
Working memory	0.080	0.040	**0.415****	**0.266****
Processing speed	**0.226***	0.167	0.112	**0.209***
Total score of cognitive ability	**0.271****	**0.229***	**0.300****	**0.357****

Math performance is indirectly affected by photographic memory in learning ability through the processing speed index in cognitive ability (Figure 8b). 3. English performance is not directly affected by learning ability. English achievement is indirectly influenced by auditory sequential memory in learning ability and verbal comprehension in cognitive ability. English performance is indirectly affected by visual sequential memory in learning ability through the working memory index in cognitive ability (Figure 8c).

4 Conclusions and Recommendations

4.1 Research conclusion

Through this study, we found that:

(1) Artificial intelligence learning ability training has significantly improved students' cognitive ability, including understanding ability, perceptual reasoning ability and working memory ability. After training, the scores of cognitive ability of the experimental group were significantly higher than those of the control group. Specifically, the comprehension score went up quite a bit to 123.75 points, from 113.80; The working memory score rose more to 121.25 points, up from 103.00 points. These data reflect the obvious improvement of students' cognitive skills and the strong self-feedback support. Many participants reported greater clarity and confidence in their research. It can be seen that AI training has significantly enhanced their cognitive ability and also helped them master the course content better.

(2) Research shows that AI learning ability is positively correlated with academic performance. Although there was no significant difference between the experimental group and the control group in the three test scores, in-depth analysis found that the AI learning ability score was positively and significantly related to the learning performance. Especially in Chinese, mathematics and English subjects, visual sequence memory and auditory sequence memory demonstrate this correlation clearly. This shows that by improving students' cognitive skills, AI learning systems can indirectly improve their academic performance effectively, demonstrating the important potential of artificial intelligence in education.

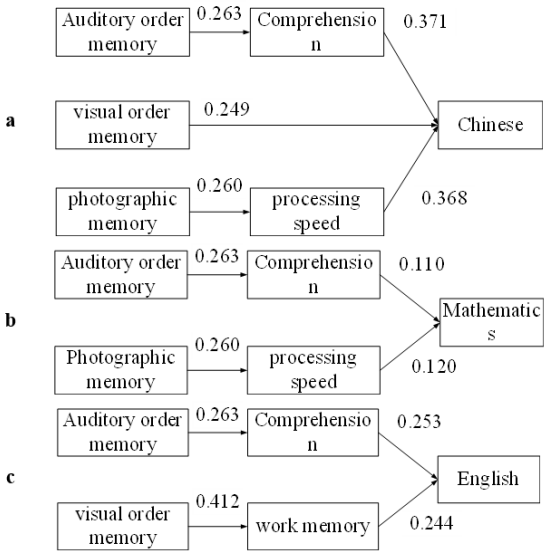

Figure 8: The influence of learning ability and cognitive ability on Chinese (a), mathematics (b), and English(c) achievement

(3) This study highlights the importance of integrating AI learning systems into teaching practices. Through systematic training, teachers can provide more targeted support to help students overcome difficulties smoothly and improve their overall performance effectively.

4.2 Research Limitations and Prospects

There are some shortcomings in this study, which are reflected in the sample selection and method. The subjects were only 120 middle school students and the homogeneity was very high, which affected the universal applicability of the results to a certain extent. Experimental design does not fully control for external factors, and factors such as learning environment and mental state may interfere with cognitive ability and performance. In addition, many variables affect students clearly. The cognitive abilities that can be developed through training are limited, as are natural genetic traits and the methods of teaching different subjects. One limitation was that the subjects (120 in all) were remarkably homogeneous (from the same school, about the same age). This weakens the validity of the conclusions on a larger scale and further discussion is necessary to strengthen the results.

Based on the above inference, it is suggested to expand the population of tested students in future research.

In the application direction, there are three exploration angles: (1) Core basic competence: assessing students' proficiency level in reading, writing, mathematics, etc. (2) Special subject skills: identifying target-related courses, such as entrance tests; Customized teaching program. (3) The adaptability of social-emotional behavior.

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