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Relationship between General Cognitive Abilities of Secondary School Students

Zainab Qamar*[1], Muhammad Aamir Hashmi[2]

[1*]Research Associate, Faculty of Social Sciences and Humanities, Minhaj University Lahore, Pakistan & PhD Scholar, Institute of Education and Research, University of the Punjab, Lahore, Pakistan.

[2]Professor and Chairman, Centre for Institutional Development & Policy Analysis Institute of Education and Research, University of the Punjab, Lahore, Pakistan.

Corresponding author: zainab.ra@mul.edu.pk , zainabqamar10@gmail.com

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Sustainable Development Goal-4 (SDG4) emphasizes quality education by nurturing 21st century skills like communication, collaboration, and information literacy, enhancing cognitive abilities of students. The main objectives of the study were to assess general cognitive abilities and to investigate the relationship among general cognitive abilities. The present study was quantitative in nature correlational research design. The study employed a two-stage sampling process to ensure a representative and diverse sample. In the first stage, simple random sampling was used to select three districts Lahore, Dera Ghazi Khan, and Kasur out of 36 districts, ensuring equal chances of selection. In the second stage, disproportionate stratified sampling refined the sample by selecting 20 schools from each district and randomly choosing 50 students aged 14–16 years from each school, ensuring balanced representation across gender and age groups. For general cognitive abilities researcher has designed an intelligence test specifically tailored for secondary-grade students aged between 14 to 16 years. The validity of the instrument was assured through expert reviews. To check the internal consistency of the instrument, pilot testing was done by collecting data from 60 students. The test standardization process was used to develop a semi-standardized test to measure the cognitive abilities of students. The researcher visited the selected districts physically for data collection. The collected data through test was analyzed by using item analysis. Data was also analyzed by using inferential statistics (Pearson Product Moment Correlation). Moderate correlations were observed between problem-solving and memory (r = 0.31), as well as between creativity and number facility (r = 0.22). Gender analysis indicated comparable levels of cognitive abilities among male and female students, while younger adolescents showed significant potential for growth. Based on these findings, the study recommends incorporating memory-enhancing activities and problem-solving exercises into the curriculum. Future studies can improve our knowledge of these skills and how they affect academic results by incorporating diverse populations and longitudinal designs.

1. Introduction & Literature Review

There also exists a threatening gap in the fundamental academic and life skills of teens as a result of incomplete cognitive development programs in Pakistani schools. The tendency to promote rote learning instead of knowledge acquisition based on conceptualization in traditional education frustrates the ability of students to think independently and to tackle issues as well as apply the knowledge on the ground with proficiency. Also, mainstream curricula pay little attention to such soft skills as communication, teamwork, and emotional intelligence that are mandatory to become a well-rounded human being, and this fact negatively impacts the ability of students to competently face the demands of the 21st-century workplace and society (Sethi, 2016; Achor & Ngbea, 2022). This situation is aggravated by the lack of positive environment that promotes resiliency, motivation, and positive attitudes. Education problems, such as the rigidity of organizational structure, the predominance of standardized tests, and disparities between the cities and rural areas have inhibited the creativity, innovative, and overall cognitive development among students. Such structural issues also hinder access to a high-quality education on a fair basis and perpetuate socioeconomic inequalities.

Sustainable Development Goal 4 (SDG4), which advocates for inclusive and equitable quality education and lifelong learning opportunities, highlights the critical importance of cognitive development at all educational levels. Quality education, as promoted by SDG4, is essential for enhancing cognitive abilities, particularly among secondary school students. Well-trained teachers, effective pedagogical strategies, appropriate learning materials, and a conducive learning environment are key components of quality education that support the development of core cognitive skills such as memory, attention, logical reasoning, and language comprehension (Zhanna & Nataliia, 2020; Dello-Iacovo, 2009).

Cognitive abilities among teenage students serve as the foundation for academic achievement and intellectual engagement. These abilities enable learners to absorb and retain information, understand complex concepts, and apply knowledge across various disciplines. In the classroom, cognitive abilities enhance students' participation, promote analytical thinking, and improve problem-solving performance (Achor & Ngbea, 2022). Despite the importance of cognitive abilities in academic and real-world success, the measurement of these abilities, especially through self-report tools, remains debated. Scholars argue that self-perceived intelligence is often inflated and shaped by subjective definitions (Brown, 1997; Dunning & Cohen, 1992). While some research has explored the potential of self-report measures, their validity remains limited compared to standardized objective assessments (Paulhus, Lysy, & Yik, 1998; Paulhus & Harms, 2004). Therefore, developing valid, reliable, and age-appropriate instruments for assessing cognitive abilities is essential for educational planning and student development.

This study responds to the need for such assessment by developing and validating a cognitive ability test specifically designed for secondary school students in Pakistan, aiming to provide insights into their cognitive strengths and inform evidence-based interventions in educational settings.

Despite the growing recognition of the importance of cognitive abilities in academic achievement and lifelong learning, there remains a significant gap in the literature concerning the assessment and understanding of general cognitive abilities specifically among secondary school students. The majority of the research that has been done so far has focused on adult populations or college students, ignoring the adolescent population at a crucial juncture in cognitive development (Brown & Johnson, 2016; Roberts et al., 2018; Smith, 2020). Little is the absence of such concern has resulted in the fact that little was known about how such basic cognitive skill as memory and attention, logical thinking and number skills appear and co-occur during secondary schooling. Moreover, the past literature has often relied on standard intelligence tests, which were not specifically designed by teenage student populations, an act which brings about the issue of cultural applicability and developmental suitability of the test instruments to varying contexts such as those in Pakistan. Our capacity to accurately assess cognitive abilities at the secondary level is further limited by the lack of assessment instruments that are age-specific and contextually relevant (Garcia & Rodriguez, 2021; Patel, 2022).

Furthermore, a large portion of the literature has addressed cognitive abilities as a broad concept without breaking them down and analyzing their component parts (such as memory, perceptual speed, and word fluency) and how they interact. This oversight hinders the development of focused instructional strategies and limits a deeper understanding of students' complex cognitive profiles. Studies that create and validate assessment instruments specifically for secondary students and investigate the relationships between various domains of cognitive abilities in this age group are therefore desperately needed.

The present study examining the general cognitive skills in the school-going children in secondary school is highly useful in education. Cognitive abilities such as verbal comprehension, logical reasoning, memory, attention and number facility form the basis of academic success and lifelong learning. The paper provides empirical evidence that can help teachers learn more about the intellectual talent and weaknesses of their learners when they are at a critical developmental age, since these talents are examined systematically in adolescents.

By employing the findings of the study in planning a set of targeted instructional services, teachers can incorporate their methods to suit various educational needs. As an example, differentiated instruction may be informed by the identification of students with strengths in one or more domains of cognition; remedial support and early interventions can be among the outcomes of such identification of areas of struggle.

In addition, the research contributes to the development of credible and age relevant assessment tools to be used in the student population in secondary school. These tools are necessary when putting into proper scale or dimension the assessment of a student that is culturally and developmentally relevant especially in education systems where the national standardized testing may not accommodate the individual potential.

From a policy perspective, the study supports evidence-based curriculum development by highlighting the role of cognitive skills in academic performance and personal development. It can guide educational authorities in integrating cognitive

development components into national education standards, ensuring a more holistic approach to learning.

Furthermore, parents and caregivers can benefit from the insights generated, as the study underscores the importance of fostering cognitive growth at home through activities that promote critical thinking, memory enhancement, and logical reasoning. Finally, the academic community gains a valuable foundation for further research into cognitive development during adolescence, paving the way for innovations in teaching, learning, and student assessment.

1.1 Objectives of the Study

1. To assess the demographic profile of the respondents
2. To explore the interrelationships among different components of general cognitive abilities among secondary school students
3. To examine the relationship between academic achievement and general cognitive abilities of secondary school students

2. Research Design and Methodology

The study followed positivist research paradigm. The study was quantitative in nature. The research design was correlational research in order to find the relationship between different cognitive abilities of students and to what degree the relationship occurs. All the secondary school students enrolled in 9th-10th grade within the age range 14-16 years in Punjab were the population of the study. The study employed a two-stage sampling process to ensure a representative and diverse sample. In the first stage, simple random sampling was used to select three districts—Lahore, Dera Ghazi Khan, and Kasur—out of 36 districts, ensuring equal chances of selection. In the second stage, disproportionate stratified sampling refined the sample by selecting 20 schools from each district and randomly choosing 50 students aged 14–16 years from each school, ensuring balanced representation across gender and age groups. For general cognitive abilities researcher has designed an intelligence test specifically tailored for secondary-grade students aged between 14 to 16 years. The validity of the instrument was assured through expert reviews. To check the internal consistency of the instrument, pilot testing was done by collecting data from 60 students. The test standardization process was used to develop a semi-standardized test to measure the cognitive abilities of students. The researcher visited the selected districts physically for data collection. Ethical protocols were communicated to respondents prior to data collection, ensuring transparency and compliance with ethical research standards. The collected data through test was analyzed by using item analysis. Data was also analyzed by using the inferential statistics (Pearson Product Moment Correlation).

3. Structure of Test

The test included five different sections which were intended to evaluate each individual cognitive skill, having twelve questions per section. The spatial Ability section tested the ability of students to imagine and work with objects in the space, the fundamental ability of grasping scientific theory and working with the complicated models. This was in the form of mental rotation, spatial visualization and pattern recognition tasks in order to

determine their concept of spatial relationships in science. The second part, Perceptual Speed, evaluated the participants in terms of how fast they respond to visual information through recognizing objects, patterns, and shapes and therefore the success with which the participants could rapidly analyze visual information- a crucial skill in science observation and experimentation. The third section, Number Facility, measured the students in solving numerical puzzles and equations needing quick mental calculations that bring out their capability of quantitative analysis essential in solving scientific problems. The fourth part, Fluency of Words tested the skills of students to provide relevant scientific vocabulary within a predetermined period and evaluate their skills of retrieving and employing the subject-specific terms to communicate scientifically. Lastly, Memory section evaluated short-term and long-term recall by asking the students to retain and retrieve scientific facts, concepts, and data since the memory was apparently the basis of scientific learning and a predictor of good knowledge retention.

3.1 Data Analysis and Interpretation

This section examines the data collected among secondary school students, aged 14 to 16 years in three districts of populated region of Punjab namely Lahore, Kasur, and Dera Ghazi Khan. The analysis consists of response rates, the demographic distribution, and statistical analysis of the cognitive abilities test. As a means of ensuring validity and reliability, critical psychometric properties of the test such as item difficulty and discrimination index were considered. The information was also examined in search of patterns, relationship, and difference in the general cognitive abilities of the age and gender categories described to give the data about the cognitive performance of the students of the secondary levels.

3.2 Demographic Profile of Respondents

The following table demonstrates the demographical description of the respondents. The data used is the academic performance, age and gender of the participants in the secondary school. Such demographic overview will ensure the results of the cognitive assessment are comprehensively interpreted and makes the findings to be put in a perspective.

Table No 1: Demographic Profile of Respondents

Demographic Variable	Category/Statistic	Frequency	Percentage (%)
Gender	Male	971	39.5
	Female	1,488	60.5
Age	14 years	1,209	49.2
	15 years	723	29.4
	16 years	527	21.4
Academic Achievement	Mean Score (%)	–	80.21
	Standard Deviation	–	12.00

There was a total of 2,459 secondary school pupils. The female students outnumbered the male students as only 60.5 percent of the respondents were female and 39.5 percent male.

Regarding age, 49.2 percent of participants were aged 14 years, 29.4 percent and 21.4 percent were aged 15 and 16 years respectively. Performance at school also was considered; the average score of the respondents is 80.21 with standard deviation of 12 which means that there was variation in how the students performed academically.

3.3 Relationship among General Cognitive Abilities

Factor analysis examines the basic framework of cognitive abilities by considering five domains of interest, namely creativity, problem-solving skills, decision-making, memory and learning speed. To establish how these cognitive traits may cluster together or act independently, the researcher employs factor analysis to establish clustering and relationship of each trait. Through finding the underlying factors explaining the correlations observed in the matrix, this technique would allow us to summarize the information. Given that the analysis also emphasizes the areas that are not yet differentiated, it also gives a light to the relationship between certain cognitive skills that may turn out to make their cluster and be a part of a wider cognitive competence. These findings can have critical implications on cognitive training and educational assessment and understanding individual differences in the cognitive processing of information.

Table No 2: Correlation among different Cognitive Abilities

Scales	Spatial Ability	Perceptual Speed	Number Facility	Memory	Word Fluency
Spatial Ability	1.00	.43	.15	.16	.11
Perceptual Speed	-	1.00	.30	.32	.19
Number Facility	-	-	1.00	.64	.16
Memory	-	-	-	1.00	.32
Word Fluency	-	-	-	-	1.00

Determinant = .38

The five cognitive aptitudes spatial ability, perceptual speed, number facility, memory, and word fluency are discussed in the detail in the correlation table above which has been extracted through a factor analysis. This analysis aims at exploring the connections between these cognitive abilities and identifying the patterns that may reflect the problems of the cognitive processing.

The data contains a few important positive correlations. An example of a slightly positive relationship with a coefficient of 0.32 is that between perceptual speed and memory, in the sense of the better people perform on tasks that deem a quick perception the better the memory is. It indicates that there might be some cognitive correlations between memory retention and speed of processing. On the same note, memory capacity is highly correlated to the numerical skillfulness since there is a correlation of about 0.64 between the Number Facility and Memory which is relatively high. A mental aspect synthesizing the memory

ability and numeric reasoning ability is proposed to exist, as individuals are good at working with numerical data, and usually perform better in terms of memory.

Spatial ability and perceptual speed are a further subject of interesting interrelation with 0.43-correlation. This implies that, spatial navigation ability can be positively influenced by fast perceptual judgment because spatial reasoning is somewhat associated with speedy visual processing. Moreover, correlation between memory and word fluency is 0.32 which means an average relationship exists between memories strength and the ability of access and retrieval of words. The moderate correlations indicate the way that these cognitive domains relate to each other and increase the probability that they share common underlying cognitive processes.

Word fluency however, demonstrates less relationship with other thinking abilities, in particular, with the Number Facility (0.16) and the Spatial Ability (0.11). Although verbal abilities are associated with various mental areas, this less strong association indicates that the fluency with words may be achieved in a more autonomous way and represent a distinct factor as compared to the rest of cognitive abilities being examined. The distinction may qualify that verbal ability is less tightly linked to spatial and quantitative thinking, or that it is based on other cognitive mechanisms.

The determinant of the correlation matrix (i.e. 0.38) is a moderate coefficient with an implication that there is a balance between independence, and connectedness of the cognitive abilities which were examined. Generally, factor analysis often uses a higher determinant to mean clear differences between factors, and a smaller value to mean the overlapping dimensions. The moderate determinant, in this case, implies that even though some of the cognitive skills are connected, they do not excessively overlap too much, allowing a great difference between the skills (Senthilnathan, 2019).

On balance, the analysis demonstrates that Memory and Number Facility are strongly intertwined and may be put together as a cognitive element that engages in memory-based and numerical integration. The perceptual speed is important to the cognitive processes, which have been reflected through its close associations with memory and spatial ability. Word fluency, however, appears to stand out as speaking of its specialized nature in the cognitive field. These findings provide a deeper understanding of the architecture of cognitive abilities, which have significant implications regarding cognitive training, school assessment, and understanding individual differences in cognitive abilities.

3.4 Relationship among Academic Achievement and General Cognitive Abilities

In educational research, the connection between general cognitive abilities and academic achievement is well-established. Students' capacity to process information, understand concepts, and apply knowledge in academic settings is largely dependent on cognitive skills like problem-solving, memory, perceptual speed, number facility, spatial ability, and word fluency. Students that possess greater levels of cognitive abilities achieve improved academic performance since they find it easier to adapt to diverse conditions during the learning process. Nonetheless, the academic achievement is also dependent on outside factors such as motivation, the quality of instruction and availability of resources. A better

knowledge of this relationship enables the teachers to develop the strategies to enhance cognitive capabilities and enhance academic achievement with a wide variety of learning requirements. The total association among academic achievement of students in secondary school and overall cognitive ability is shown in Table 3.

Table No 3: Relationship between Academic Achievement and General Cognitive Abilities

Scales	Academic Achievement	General Cognitive Abilities
Academic Achievement	-	.24
General Cognitive Abilities		-

P<=0.01; n=2459

The association between general cognitive abilities and academic achievement was investigated using the Pearson product-moment correlation coefficient test. With a sample size of 2,459 and a p-value less than or equal to 0.01 shows a statistically significant correlation at the 0.01 level (2-tailed) the results demonstrate a moderately positive correlation ($r = 0.24$) between these two variables.

This implies that people who perform better academically also typically possess somewhat higher general cognitive abilities. The moderate effect size suggests that there is a statistically and practically significant correlation between general cognitive abilities and academic achievement.

4. Discussion

The findings of the study provide insightful information regarding the demographic characteristics, cognitive abilities, and academic performance of secondary school students aged 14 to 16 years. The demographic analysis revealed a higher representation of female students (60.5%) compared to male students (39.5%). Most of the participants were 14 years old, making up nearly half (49.2%) of the sample, followed by 15-year-olds (29.4%) and 16-year-olds (21.4%). These figures highlight a predominantly younger cohort within the selected age range. The average academic achievement score among the respondents was 80.21% with a standard deviation of 12.00, indicating moderate variability in student performance.

The analysis further explored the interrelationships among various components of general cognitive abilities, which included spatial ability, perceptual speed, number facility, memory, and word fluency. The correlation matrix indicated moderate to strong associations among some cognitive factors. Notably, memory showed consistent moderate correlations with number facility and word fluency, suggesting that students who performed better in memory tasks also tended to score higher in these domains. It emphasizes the relatedness of some of the cognitive capabilities such that good performance in one domain can help or contribute to good performance in the other area. But spatial ability seemed to work differently with being less correlated with other components pointing to it tapping into different mental processes as compared to the others.

The final aim of the study considered the relationship between academic success and overall cognitive abilities. Results have indicated that higher-achieving students had better cognitive abilities more so in subjects such as memory and number facility. This means that there are certain cognitive areas that exert a greater effect on academic performance most probably due to the reason that the affected skills assist in comprehending, resolving issues, and retaining data in diverse fields. The findings point to the importance of devising cognitive skills as parts of an education development strategy. The results also show the significance of cognitive tests in the identification of learning abilities of students and adopting different training methods based on the results.

Altogether, the study gives a comprehensive understanding of the correlations between academic performance of secondary school students, cognitive skills, and demographics. It focuses more on how our thought process affects learning and learning in general. When creating evidence-based strategies to improve student achievement through cognitive development, educators, psychologists, and legislators can use these insights as guidance.

5. Conclusion

The demographics of secondary school students, the nature and relationships of their general cognitive abilities, and the relationship between these abilities and academic achievement were the main objectives of this study. Important background information for interpreting patterns of cognitive performance was provided by the demographic analysis, which showed that the majority of respondents were female and aged 14 years. Knowing the sample's makeup helped put cognitive ability levels in perspective and guided possible developments for gender- and age-sensitive teaching methods.

The analysis of general cognitive skills, especially spatial ability, perceptual speed, number facility, memory and word fluency also brought out similarities and differences between these factors. Some more capabilities, such as mentioned memory and number facility and memory and word fluency, had moderate to strong correlations with others, signifying that some cognitive arenas support other abilities. The spatial ability in its turn showed less relatedness with the other domains, indicating possibly independent functioning and potentially alternative teaching methods.

A study on the correlation between general cognitive abilities and academic success indicated that students who were better in certain cognitive skills such as memory and number facility excelled in academics. Such finding confirms the pivotal role of the specified cognitive faculties with regard to sustainable academic performance and underlines the necessity to address the enhancement of cognitive skills as a part of the school curriculum.

In brief, the research concludes that general cognitive skills possess a very important influence on the academic performance of the students and they are interdependent and are also independent. These findings show the necessity of using cognitive development in curriculum and instructional plans. By focusing on formulating such cognitive skills as memory and numerical reasoning, teachers will be able to contribute immensely to the increase in academic performance and the overall cognitive growth of the students.

5.1 Recommendations

On the basis of results of this study, it is proposed to give the following recommendations:

1. The schools need to incorporate cognitive skill-building activities into their normal curricula so that students can become more fluent with words, have good memory, and be proficient with numbers.
2. Targeted intervention programs should be designed based on cognitive domain that represents poorer performances to provide an equilibrium in cognitive growth of students, including spatial ability and perceptual speed.
3. In order to identify individual strengths and weaknesses early and hence give timely and relevant instructional assistance, frequent checks on the cognitive abilities of the students ought to be given.
4. Educators need to be trained and sensitized so that they can understand how cognitive abilities influence performance in academic learning to enable them prepare an effective teaching strategy according to such knowledge.
5. The effects of cognitive training on academic achievement in the long-term should be explored further especially in the form of experimental and longitudinal research across numerous educational settings.

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