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Relationship of Metacognition with Academic Performance of Prospective Teachers: Modeling Mediation Effect of Digital Literacy

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This study inspects the relationship between metacognition and academic performance among prospective teachers while modelling the mediation effect of digital literacy. The study was quantitative in nature. In the positivistic paradigm of research, the quantitative relational research design was the most appropriate research design for the study. 9,680 participants enrolled in a four-year program, i.e. BS Education and B. Ed at the Department of Education in the 23 universities of Punjab Province were the population of the study. A sample of 976 prospective teachers was selected from five divisions of the province of Punjab through a stratified random sampling technique representing the three zones of Punjab: north, central and south. Metacognitive awareness inventory (MAI) by Schraw and Dennison (1994) and the digital literacy scale by (Amin et al., 2021) were adapted after proper permission from the authors. Through SPSS 21.0, descriptive and inferential statistical techniques were applied for data analysis. AMOS 26.0 was used to test theory derived causal hypothesis and to run the mediation analysis through structural equation modeling (SEM). Analysis of data metacognition had positive relationship with metacognitive regulation (p<.001), metacognitive knowledge (p<.001), academic motivation extrinsic (p<.001), academic motivation intrinsic (p<.001), total digital literacy (p<.01), digital literacy communication (p<.01), digital literacy copyright (p<.001), digital literacy critical (p<.001), digital literacy character (p<.001), digital literacy citizenship (p<.001), digital literacy curation (p<.001), digital literacy connectedness (p<.001), digital literacy creativity (p<.001), digital literacy collaboration (p<.001) and CGPA (p<.001). Chi-square (X^2) was non-significant ($X^2 = 3.42$, $p > 0.05$), indicating acceptable model-data alignment. Additionally, RMSEA fell within the recommended range (RMSEA = 0.05), suggesting a low level of error approximation. Further supporting the model's adequacy, CFI, TLI, and GFI all exceeded the 0.95 benchmarks (CFI = 0.99, TLI = 0.99, GFI = 0.99), signifying strong relative fit. Findings revealed that metacognition was positively related to the academic performance of prospective teachers. The results found that digital literacy has a strong moderating influence on the association between metacognition and academic achievement among prospective teachers. Metacognition and digital literacy are found to play a significant effect in improving prospective teachers' academic performance. It is recommended for future studies that examining specific aspects of digital literacy in more depth could yield valuable insights. For instance, research might delve into the role of information fluency or the ability to manage online identities in relation to other indicators of academic success.

1. Introduction

Metacognition is the activity of monitoring, controlling, and regulating the cognition of an individual of his own. Metacognition is the ability of when and how to apply specific learning and problem-solving techniques (Riley, 2023). Metacognition is "thinking about thinking" and the ability to help students in learning how to learn. According to Rosch and Lloyd (2024), it is "knowing about knowing" or "cognition about cognition".

Metacognition has two subcomponents: metacognitive knowledge and metacognitive regulation. The subcomponents of metacognitive knowledge include procedural, conditional and declarative knowledge. There are three components of metacognitive regulation: planning, monitoring, and evaluating (De Backer et al., 2022). There has been growing acceptance that metacognition, including awareness of ourselves as learners and self-regulating ability, helps us learn more effectively (Coskun, 2018). Metacognition is a significant predictor of academic success. There is a positive association between students' metacognitive awareness and their academic performance. Students who can effectively reflect on and manage their learning processes tend to achieve higher academic results (Dunning et al., 2003).

According to Chan (2024), digital literacy refers to the ability to analyze, access, and use digital technology and networks to successfully discover and generate knowledge. Additionally, it describes the capacity of an individual to carry out tasks successfully in a digital environment or the capacity to comprehend and utilize data offered in numerous formats and from various sources when generated by technology.

The researcher (Audrin & Audrin, 2022) reported that due to global change, digital literacy is a driving force behind learners' behaviour and a vital component of technology innovation. In contexts of rapid change in the 21st century, metacognitive strategies provide distinct advantages to expert or competent students in computing environments. They may be more important than the skills themselves. Educators can now nurture learning abilities that reflect the course, distinct learning styles, and use of digital technologies (Tejedor et al., 2020). Digital literacy is a comprehensive structure that fosters the acquisition of information, competencies, and ethical insights in the digital realm (List, 2019). A framework outlined by Chen et al. (2023) identified that digital literacy has nine competencies: communication, copyright, citizenship, connectedness, critical thinking, curation, collaboration, character and creativity.

For the professional development of future teachers, university education serves as a transformative experience that encourages individuals to realign their career goals and enhance their abilities. This study is noteworthy as it emphases on highlighting the importance of metacognitive awareness in Higher Education contributing to the literature on how metacognitive processes influence educational outcomes. The research has far-reaching implications in benefiting educators other than beyond teacher education, who recognize that improved metacognitive skills can boost student performance. Additionally, this study provides a basis for exploring the connections between metacognition and digital literacy. Finally, the findings will be essential for teacher training institutions, highlighting the need to prepare future educators with a better

understanding of digital literacy in technology-driven educational landscapes for promoting student engagement during the teaching-learning process.

The objective of the study was to analyze the relationship of prospective teachers' metacognition and digital literacy with their academic performance. The other objective was to determine the mediation effect of digital literacy between prospective teachers' metacognition and academic performance. By focusing on prospective teachers, this research aimed to explore how to equip future educators with the necessary digital skills to promote metacognitive learning in their students. Thus, it was hypothesized that metacognition is likely to correlate with the academic performance of prospective teachers and digital literacy to mediate the relationship between metacognition and the academic performance of prospective teachers.

2. Literature Review

There is a positive relationship between success in various subjects and education level. A study by Rimawi and Rimawi (2020) identified a positive correlation between metacognitive knowledge and academic performance among university students. Students with higher levels of metacognition report better academic performance in many subjects. Similarly, Santangelo et al. (2021) reported that students with strong metacognitive abilities showed better academic performance in science. These studies show that metacognition is an important factor affecting learning success in different learning environments.

Many studies (Peng & Kievit, 2020) reported that when inquired about dealing with an individual’s cognitive abilities and available learning techniques in novel settings, learners behaved more critically than the limited content knowledge they may possess, so awareness of their mental understanding and metacognitive regulatory skills are needed and valuable for learning and processing digital technology (Lara Nieto-Márquez et al., 2020).

Research showed that students with higher digital literacy will receive better grades and test scores (Yustika & Iswati, 2020). Students with strong digital literacy skills excel in subjects such as science, technology, engineering and mathematics (STEM). These findings suggest that digital literacy enables students to use digital learning resources and complete academic tasks more effectively.

Research shows that digital literacy skills improve students' thinking and problem-solving skills. Students develop skills in evaluating data, identifying biases, and creating effective arguments by using digital tools for research, analysis, and design (Mohammadi, 2024). These important skills are essential for success in higher education, ultimately improving academic performance. Online learning and digital communication tools allow students to work together on assignments, share ideas, and receive feedback from their fellows and teachers (Coşkunserçe & Aydoğdu, 2022).

There is limited literature on these topics, specifically for students in Pakistan. The present study addressed the gap by exploring the relationship of metacognition with the academic performance of prospective teachers while modelling the mediation effect of digital literacy. This study specifically investigates the digital literacy skills of prospective teachers. Prior research suggests a connection between digital proficiency and the use of metacognitive strategies among

educators. Educators who effectively utilize metacognitive strategies are likely to create more successful learning environments for their students.

Siraj et al. (2022) explored the connection between medical students' metacognitive awareness regarding reading strategies and their academic success in Pakistan. The results show a positive relationship, indicating that students who possess a greater awareness of effective reading techniques such as summarizing essential points, recognizing primary arguments, and critically assessing information are likely to attain greater academic outcomes. This finding is consistent with prior studies that emphasize the impact of metacognition in facilitating effective learning (Perry et al., 2019; Schraw, 2013).

Ali et al. (2022) examined the impact of metacognitive skills on the academic performance of future educators. The results indicated that training focused on developing and enhancing metacognitive skills to make it more effective for teaching-learning purposes among prospective teachers.

Parveen et al. (2024) conducted a study to find out the connection between digital literacy and academic performance in universities throughout Pakistan. Their results revealed that students with high digital literacy demonstrated better communication skills, likely due to their ability to use online platforms regularly and to express their ideas clearly in digital settings. Furthermore, the research highlighted a significant association between digital literacy and research skills, suggesting that this literacy enables students to effectively utilize online resources, access credible information, and conduct thorough research. The literacy skills, in turn, deepen their understanding of academic subjects, so the students with higher levels of digital literacy may also have increased self-confidence.

In conclusion, the positive impact of digital skills on student learning is becoming a more significant area of research in Pakistan. However, the vital role of metacognition remains less focused. Investigating this aspect could provide valuable insights for using effective metacognitive strategies which can help Pakistani students improve their learning and attain academic success. This identified research gap presented a significant opportunity for conducting a present study in Pakistan.

3. Research Methodology

The study was quantitative in nature. In the positivistic paradigm of research, quantitative relational research design was the most appropriate research design for the study (Kumatongo & Muzata, 2021). The primary purpose of this quantitative relational research (Bloomfield & Fisher, 2019) was to form and test the theoretical model so data collected through research instruments yield quantitative scores. Quantitative relational research involves the systematic investigation of relationships between variables using statistical methods (Tijdink et al., 2024)**.**

3.1 Population and Sample

9,680 participants enrolled in a four-year program, i.e. BS Education and B. Ed at the Faculty of Education in the 23 public universities of Punjab Province were the population of the study. To determine an appropriate sample size for the current study, the researcher considered the guidelines provided in the literature (Rahman, 2023). Typically, a sample size of 10-30% of

the population is considered appropriate for quantitative research. Therefore, for a population of 9,680 participants, a sample size of approximately 958 to 2,904 would be appropriate (Hossan et al., 2023). Through multistage stratified random sampling, a sample of 976 prospective teachers was taken. After applying the advanced statistics (Adhikari, 2021), 16 outliers were identified and excluded from the sample. So, the sample of 960 participants was finalized.

3.2 Sampling Technique

A multistage stratified random sampling technique was aimed to select a representative sample of 976 prospective teachers from the province of Punjab, encompassing seven general category public universities and including participants from six districts of five divisions (HED, GoP, 2024). This approach helps to minimize selection bias and improve the generalizability of study findings to a wider population of future educators in the province of Punjab. Five divisions of the Province of Punjab were selected for representation of the diverse geographical landscape, so data were collected from all three zones, i.e. central, north and south zones of the province of Punjab, Pakistan. Furthermore, seven universities from six districts were selected randomly. The participants ranged in age from 16 to 32 (M=20.78 years, SD=1.75). Participants from the 2nd to 7th semesters enrolled in a four-year program, i.e. BS Education and B. Ed at the Department of Education in the selected universities of Punjab Province, were sampled for the study.

Table No 1: Demographics showing sample characteristics (N=960)

Demographic Characteristics	F	%
Zones		
Central	343	35.7
North	300	31.3
South	317	33
University*		
A1	95	9.9
A2	94	9.8
A3	154	16
A4	139	14.5
A5	161	16.8
A6	161	16.8
A7	156	16.3
Programs		
BS Education (4 years)	292	30.4
B. Ed (4 years)	668	69.6
Semesters		
2nd	171	17.8
3rd	229	23.9
4th	84	8.8
5th	219	22.8
6th	24	2.5
7th	233	24.3

*A1= IUB, A2=BZU, A3=UE,A4=UAF,A5=UoJ,A6=FJWU,A7=AAUR

3.3 Demographic information sheet

The researchers employed a self-developed demographic questionnaire. This questionnaire collected data on participants' gender, age, semester, program and scholastic achievement (CGPA) as indicators of academic performance.

3.4 Instrumentation

The metacognitive awareness inventory of (Schraw & Dennison, 1994) were adapted to assess metacognition, and the digital literacy scale (DLS) by Amin H. et al. (2021) was adapted to analyze the mediation effect of academic motivation and digital literacy on academic performance. The researcher measured the prospective teachers' academic performance by their CGPA.

3.5 Metacognitive Awareness Inventory (MAI)

Participants' levels of metacognitive awareness and metacognitive regulation were assessed using the Metacognitive Awareness Inventory. MAI, developed by Schraw and Dennison (1994), consisted of 52 True/False questions that were adapted to a five-point Likert scale format ranging from “I never do this” to “I do this always.” This assessment is largely used, and validity and reliability measures are available (Robinson, 2024). Schraw and Dennison (1994) reported high internal consistency scores for the instrument .91 on each factor of the MAI and .95 for the entire MAI. In the present study, we obtained an alpha coefficient for metacognitive inventory was .89. Furthermore, we obtained an alpha coefficient for knowledge of cognition and regulation of cognition is .75 and .84, respectively. As evidenced by research (Alam, 2020), the positive correlation between MAI scores and student academic achievement supports the instrument's external validity.

3.6 Digital Literacy Scale (DLS)

Digital Literacy Scale (DLS) (Amin et al., 2021) was used in this research to assess the digital literacy scale of prospective teachers. The scale originally consisted of 36 items comprised of subscales based on 9 C’s which are communication, copyright, citizenship, connectedness, critical thinking, curation, collaboration, character and creativity. It has a five-point Likert-type rating scale. Values of Cronbach’s alpha showed that each dimension has a score higher than 0.7, which is an acceptable value (Adeniran, 2019). Value for copyright .86; communication.89, critical thinking .82; citizenship .80; character.87; curation .74; creativity .82; connectedness .76 and collaboration .78. Overall, DLS has .90 Cronbach’s alpha value, which shows that the reliability of the scale is quite high (Amin et al., 2021). The validity of the instrument was established by the panel of experts in the relevant field in order to seek the construct validity of the scale against the said dimensions of the digital literacy scale (Clark & Watson, 2019). After the pilot study, keeping in view the comments and suggestions, changes were made to the instrument and the scale of 27 items as the instrument (DLS) was adapted so the consistency of the instrument was measured by the researcher. The Cronbach’s alpha for DLS was good in the present study which was .89 for total scale.

3.7 Data collection

The present research received ethical approval from the Advanced Studies and Research Board (BASAR) at The Islamia University of Bahawalpur, Pakistan. Additionally, permission to

utilize the specific measurement scales employed in the study was obtained from the respective authors. The researcher visited the chosen universities and secured permission from the relevant authorities, such as administrators, directors, or chairpersons. To ensure clarity, relevance, and appropriate completion time, a pilot study was conducted. This initial testing phase confirmed that the questionnaire items were well-understood by participants fully for the Metacognitive Inventory, but 9 items which were rated lowest in score by the participants were removed from the final questionnaire from the Digital Literacy Scale.

After the pilot study, the main phase of the research was conducted. A standardized procedure for data collection was followed (Swain et al., 2022). Informed consent was provided to participants with a form to review and sign, ensuring their awareness of the study's nature and purpose. They then completed a demographic information sheet followed by the questionnaire. Throughout the process, the confidentiality of their responses was emphasized (Suri, 2020), assuring them that the information would be used solely for research purposes questionnaire was individually administered, and participants filled out the Metacognitive Awareness Inventory (MAI) and the Digital Literacy Scale (DLS). Scholastic achievement (CGPA; Cumulative Grade Point Average) was sought by the researcher to determine the academic performance of the participants.

3.8 Data Analysis and Findings

SPSS 21.0.0 and AMOS 26 were used to execute data analysis. Descriptive analysis was used to describe the zones, universities, programs and semesters. Pearson Product Moment correlation was used to explore the relation of metacognition, academic performance and digital literacy of prospective teachers. Structural Equation Modeling (SEM) employed using AMOS to investigate the mediating role (Mustafa et al., 2020) of digital literacy in the relationship between metacognition and the academic performance of prospective teachers.

Table No 2: Pearson Product Moment Correlation of Metacognition, Digital Literacy with their subcomponents and academic performance

		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	**Age**	1												
2.	**Total MC**	.053	1											
3.	**MC Regulation**	.050	.969**	1										
4.	**MC Cognition**	.049	.898**	.762**	1									
5.	**Total DLS**	.101**	.386**	.378**	.339**	1								
6.	**DLS Communication**	.072*	.350**	.344**	.305**	.870**	1							
7.	**DLS Copyright**	.114**	.322**	.311**	.290**	.796**	.589**	1						

8.	**DLS Critical**	.032	.244**	.241**	.211**	.576**	.446**	.396**	1				
9.	**DLS Character**	.085**	.254**	.241**	.237**	.766**	.578**	.576**	.441**	1			
10.	**DLS Citizenship**	.068*	.330**	.323**	.289**	.807**	.637**	.629**	.512**	.560**	1		
11.	**DLS Curation**	.051	.219**	.212**	.197**	.629**	.516**	.418**	.319**	.397**	.405**	1	
12.	**DLS Connectedness**	.046	.267**	.271**	.217**	.715**	.571**	.483**	.340**	.480**	.477**	.493**	1
13.	**DLS Creativity**	.097**	.181**	.187**	.142**	.578**	.439**	.395**	.242**	.437**	.366**	.322**	.363****	1

MC= Metacognition, DLS= Digital Literacy Scale, CGPA= Cumulative Grade Point Average (Academic Performance Indicator)

*p<0.05; **p<0.01; ***p<0.001

4. Statistical Analysis

4.1 Descriptive analysis

Table 1 shows that among the three zones, central zone; among the universities S1 (university of south zone); B. Ed and 7th semester was the most dominant and frequently reported.

4.2 Pearson Product Moment Correlation

Pearson Product Moment Correlation was executed to assess the relationship among metacognition, academic performance and digital literacy. Table 2 showed that metacognition (knowledge of cognition and regulation of cognition) was positively related to academic performance (CGPA). It showed that metacognition was associated with more with academic performance of prospective teachers. Furthermore, metacognition was positively related to digital literacy. Lastly, subcomponents of digital literacy (communication, copyright, citizenship, connectedness, critical thinking, curation, collaboration, character and creativity) were positively related to academic performance.

Table No 3: Standardized estimates of direct effects, indirect effect and confidence intervals of metacognition on digital literacy and academic performance. (N=960)

Variables	B	95% CI for B		SE B	B	R^2	ΔR^2
		LL	UL				
Step 1						.10	.10
Constant	2.11	1.89	2.34	.11			
Total MC	.006	.005	.007	.001	.317		
Step 2						.14	.14
Constant	1.99	1.77	2.21	.11			
Total MC	.004	.003	.005	.001	.23		
Total DLS	.005	.003	.006	.001	.22		

Note: CI=confidence interval; LL=lower limit; UL=upper limit; Total MC= the collective metacognition; Total DLS=the collective digital literacy

*p < .05, **p < .01, ***p < .001

4.3 Mediation Analysis

The present study proposed that digital literacy (communication, copyright, citizenship, connectedness, critical thinking, curation, collaboration, character and creativity) is likely to mediate the relationship between metacognition (knowledge of cognition and regulation of cognition) and academic performance (scholastic achievement; CGPA) of prospective teachers. To evaluate the proposed hypothesis, a Structural Equation Model (SEM) was employed. The model utilized a maximum likelihood (ML) estimation approach. The fit indices for this model are presented in Table.

Table No 4: Model fit indices for metacognition, academic performance and digital literacy

	X^2	P	X^2/df	CFI	TLI	GFI	RMSEA
Model	3.42	.06	3.42	.99	.99	.99	.05

Assessing overall model fit is crucial in SEM analysis (Hair Jr et al., 2021). While AMOS offers various fit indices, this study focuses on those recommended by West et al. (2023).

The study used a set of fit indices: Chi-Square (X^2), Normed Chi-Square (X^2/df) Goodness-of-Fit Index (GFI), Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA).

The Chi-square (X^2) test has traditionally been the method of choice to evaluate model fit in SEM (Thakkar, 2020). This test is the only significant test in AMOS. Note: a non-significant Chi-square statistic is often used as an indicator that the hypothesized model fits accurately with the sample (Pavlov et al., 2020). Nonetheless, it should be noted that Chi-square can be very sensitive to things like sample size and data normality (Duke et al., 2020). Thus, it is recommended by the researchers to also look at other fit indices in addition to Chi-square. This includes recommendations, for example, on CFI, TLI, GFI and RMSEA (Foroudi & Foroudi, 2023). For instance, Almaleki (2021) suggest that, for continuous data, an RMSEA value below 0.06 and CFI, TLI, and GFI values above 0.95 indicate a good model fit. The final model demonstrated a good fit to the data. Chi-square (X^2) was non-significant ($X^2 = 3.42$, $p > 0.05$), indicating acceptable model-data alignment. Additionally, RMSEA fell within the recommended range (RMSEA = 0.05), suggesting a low level of error approximation. Further supporting the model's adequacy, CFI, TLI, and GFI all exceeded the 0.95 benchmark (CFI = 0.99, TLI = 0.99, GFI = 0.99), signifying strong relative fit.

Figure No 1: SEM Analysis

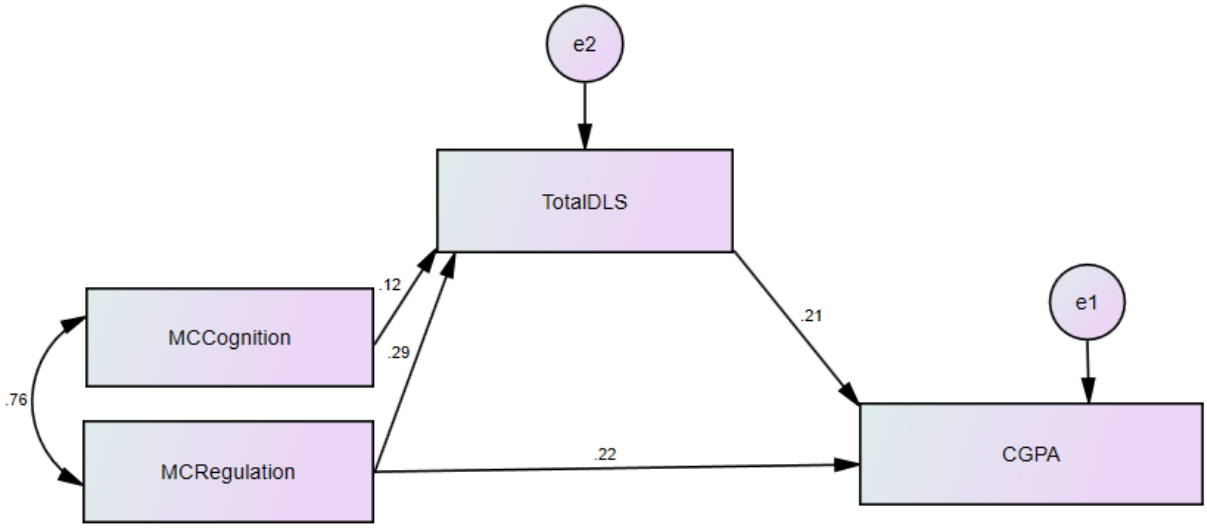

Table No 5: Standardized Estimates of Direct Effects of MS and DLS on CGPA

Variables	DLS			CGPA		
	B	**SE B**	**B**	**B**	**SE B**	**β**
MC Cognition	.27**	.10	.12**	-	-	-
MC Regulation	.35***	.06	.29***	.01***	.00	.22**
DLS	-	-	-	.01***	.00	.21***

** p < .01; *** p < .001

The present study investigated the direct relationships between the variables within the mediation model. It was hypothesized for the direct effects that metacognition is likely to positively predict academic performance. For indirect effects, it aimed to investigate whether digital literacy functions as a mediator in the relationship between metacognition and academic performance among prospective teachers. The analysis focused on testing this hypothesis about the indirect effect of digital literacy. Table 5 shows that metacognition was positively predicting academic performance. It suggested that as metacognition increased, academic performance also increased.

Table No 6: Standardized Estimates of Indirect Effects of MS on CGPA with DLS as Mediator

Variables	CGPA		
	B	**LB**	**UB**
MC Cognition	**	.01	.05
MC Regulation	***	.04	.08

** p < .01; *** p < .001

To determine whether digital literacy significantly functions as a mediator between metacognition and academic performance, the indirect effects were calculated within the mediation model. Table 6 shows that the findings support the hypothesis that the relationship between metacognition and academic performance is significantly influenced by digital literacy.

4.4 Discussions

The present study examined the mediating role of digital literacy in the association between metacognition and the academic performance of prospective teachers. The findings provide valuable insights into the complex factors influencing academic success in this population but also raise new questions for future research. There is a positive correlation between age and various aspects of digital literacy, such as overall digital literacy, communication, copyright, character, citizenship, creativity, and collaboration. Previous research has shown a connection between age and the development of digital literacy skills. Prensky (2009) coined the term "digital natives" to refer to younger individuals who grow up surrounded by technology, often acquiring digital skills intuitively, whereas elder individuals with more exposure may exhibit greater digital literacy due to their vast learning experiences (Evans & Robertson, 2020).

The current study reveals that both metacognitive knowledge and regulation are positively related to academic performance. Earlier research (Hayat et al., 2020; Stanton et al., 2021; Taghani & Razavi, 2022) also confirmed the relationship between metacognition and academic achievement. Findings indicated that students with strong metacognitive skills are more likely to practice effective learning strategies, ultimately leading to better academic results. This aligns with the present study results regarding the positive correlation between metacognition and cumulative grade point average (CGPA).

The positive relation found between metacognition and digital literacy in this study is consistent with other studies reported in the literature (Arjaya et al., 2023). These findings underline the interconnectedness of these constructs in promoting effective learning. Metacognitive awareness is essential for self-regulated learning and significantly boosts student engagement (Arsyad & Villia, 2022). Additionally, the use of digital tools in educational environments has been linked by Dancsa et al. (2023) to increased student motivation and enhanced academic performance. The strong connection between digital literacy and metacognition emphasizes the significance of digital expertise in developing higher-order thinking (Bravo et al., 2021). The results demonstrated a good model fit. This shows that the hypothesized relationships between the variables (metacognition, academic performance and digital literacy) were well-supported by the data. Metacognition directly and positively influenced academic performance. This aligns with previous research of Acosta-Gonzaga and Ramirez-Arellano (2021), who found that students with stronger metacognitive skills had higher academic achievement.

The study's key finding is the significant mediating role of digital literacy between metacognition and academic performance. Prospective teachers with stronger metacognitive skills likely use their digital literacy competencies to enhance their learning and ultimately achieve good results. Communication, collaboration, critical thinking, and information literacy are the range of abilities in a digital environment which are indicators of digital literacy (Masenya, 2021). By

fostering these skills, teacher education programs can equip prospective teachers to develop and polish their metacognitive skills for better academic performance and prepare them for technology-rich learning environments (Cai et al., 2023).

5. Conclusion

Based on the results, this study concludes that metacognition and digital literacy are a strong predictor of academic achievement for prospective teachers. This highlights the importance for teacher education programs to mould these skills into their curriculum, given that digital literacy plays such a strong role in mediation. To this end, teacher educators should be encouraged to foster metacognitive knowledge in digital learning practice and cultivate teachers who are competent with digitally-mediated literacies able to support the designs we make for deeply-digital generations of learners.

5.1 Limitations of the Study

Due to the researcher's time and budget limitations, the study was delimited to only general category public universities of five divisions of Punjab representing each of the three geographical zones of Punjab Province, i.e., south, central, and north zones. The sample size and specific characteristics of the prospective teachers might not be generalizable to all teacher education programs. Additionally, the research depends on self-reported data, which can be susceptible to biases. Future studies could benefit from employing larger and more diverse samples, as well as incorporating objective measures of metacognition, digital literacy skills, and academic performance.

5.2 Compliance with ethical standards

- All participants provided informed consent.
- The anonymity and confidentiality of all participant data were ensured. Participant identification codes were assigned, and data was anonymized during analysis and reporting.
- Measures were taken to minimize any potential risks associated with the research.
- The research methods were designed to avoid causing any physical, psychological, or emotional distress to participants.
- Research findings were reported accurately and objectively. The researchers avoided misinterpreting or manipulating data.

5.3 Future Recommendations

As digital literacy emerged as a significant mediator in this study, future research can explore other potential mediating variables. Academic motivation and self-regulation skills continue to be relevant areas of investigation (Borkowski & Thorpe, 2023). Additionally, examining specific aspects of digital literacy in more depth could yield valuable insights. For instance, research might delve into the role of information fluency or the ability to manage online identities in relation to academic success.

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