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# ENHANCING COMMUNICATION AND COLLABORATION THROUGH AI-BASED LEARNING: EVIDENCE FROM AN EXPERIMENTAL STUDY AMONG SECONDARY SCHOOL STUDENTS

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## ABSTRACT

*Artificial Intelligence (AI) in the field of education has become a more and more commonly discussed topic in the academic world since it can contribute to the improvement of 21st-century skills, especially communication and teamwork. However, there is limited empirical evidence on the context of secondary schools in the developing countries. In this regard, this research study explores the effects of AI-based instruction on both communicative and collaborative skills of secondary students in Karachi, Sindh, with a pre-post experimental design. This experiment enrolls a group of high-school pupils who enacted an AI-based teaching module designed in accordance with fostering an interactive learning process, a group discussion, and collaborative problem solving. Information was collected using instruments and standardized assessments which evaluated communicative and collaborative skills at baseline and later on after the intervention. Wilcoxon Signed-Rank Test (non-parametric) were implemented to identify changes in the level of skills among students. Findings have shown that both communication and collaboration competencies were significantly better after the interaction with AI-mediated learning, although the improvement in collaboration was slightly higher. The implications of these findings are that the AI-enhanced environments applied with the help of appropriate pedagogic techniques can effectively develop interpersonal and teamwork skills in second school learners. The research is based on the Technological Pedagogical Content Knowledge (TPACK) framework and the Social Constructivist theory and emphasizes the need to provide AI implementations with purposeful instructional design and sociocognitive interaction in order to maximize educational performance. The research has the contribution of providing empirical data related to a Pakistani-based secondary school environment and suggests practical implications of researchers, policy-makers, and curriculum developers who want to leverage AI to develop holistic skills in schools.*

***Keywords:*** *Artificial Intelligence, Communication Skills, Collaboration Skills, Secondary Education, Pre–Post Experimental Study, TPACK, Social Constructivism*

## INTRODUCTION

The new opportunities that artificial intelligence (AI) offers to the educational process are gradually reshaping modern life in the education sector and creating new opportunities in the learning process and interaction (Luckin et al., 2016; Baker and Siemens, 2018). AI includes computational systems that can perform activities traditionally carried out by human beings, including natural-language processing, pattern recognition, adaptive feedback and data-driven personalization (Almalki et al., 2021). Scholarship in the recent past has started to look into how AI affects the academic performance, as well as the development of soft skills, especially communication and collaboration, which are believed to be the key to success in the 21st-century economy (Kang et al., 2022). In a more and more digitalized world,

learners have to learn to express themselves in a variety of diverse cultural settings and AI can serve this role by ensuring prompt feedback and scaffolding of the conversation (Nguyen and Lee, 2023).

In the high- and middle-income nations, the integration of AI through experimentation is aimed at improving communication and collaboration. A case in point is Estonia AI Leap programme that provides secondary school children with AI applications and educates educators on how to become more digital and teach learners to work in teams and solve problems together (Estonian Ministry of Education and Research, 2021; Kumar and Saini, 2022). In shifting the focus of instruction away from memorization onto the learner-focused, interactive experience where AI is used as an addition and not a substitution of human educators, such massive policy campaigns prove that AI has a transformative ability to make classroom teaching and learning models more active in the 21st century (The Guardian, 2023).

Empirical studies continuously reinforce the opinion that AI has the potential of enhancing communication and cooperation within the educational environments (Hasan et al., 2024; Zhao and Wang, 2022). To illustrate, Hasan, Nasreen, and Rasul (2024) established that the predictive value of the AI-mediated tools demonstrated a positive outcome on the student cooperation and communication on university level courses. The same was obtained as a result of the research of AI-enhanced teamwork projects that encourage teamwork and socialization (Bialik and Desmarais, 2020). In theory, AI has the capacity to scaffold social interactions by initiating conversation, proposing feedback loops through artificial intelligence, and dynamically structuring groups, thus significantly decreasing mental demands and making students concentrate on the production of meaning and interpersonal communication (Cummings and Paliwal, 2021). Communal AI apps like chatbots, virtual assistants, and feedback systems establish common areas of proximal growth and promote the construction of meaning socially and the negotiation of the problem-solving (Sahin et al., 2022).

There has been both a big picture and an intricate and situation-specific challenge characterizing the rapid proliferation of artificial intelligence (AI) in K-12 education. Although many researchers state that AI has an opportunity to improve communication and cooperation with peers among students (Baker and Smith, 2020; Li et al., 2021), some researchers warn that the excessive use of digital technologies may limit face-to-face communication, especially when a student would rather use technologies to interact with peers or a teacher than use the benefits of the physical environment (Kumar et al., 2019; Gomez-Perez et al., 2022). The results indicate the need to plan pedagogy; the implementation of digital platforms does not necessarily develop soft skills unless the instructors are actively involved in putting together and facilitation of collaborative actions (Li et al., 2020; Chen et al., 2021).

The study of the effects of AI on the Pakistani context is still young, especially at the secondary-school level. The current literature has put much emphasis on student perception and academic performance instead of objective variations in communication and collaborative team work after AI-enhanced teaching (Khan et al., 2022; Ahmed and Qureshi, 2021). Recently, a controlled trial study conducted by Khairpur Mir found that courses based on AI teaching English language enhanced students oral proficiency, but they did not have pre-/ post-tests on collaborative skills (Hussain & Ali, 2022). Similarly, the survey conducted at secondary schools of Karachi shows that teachers also believe in the potential of AI but are concerned about the lack of professional training and context-specific assistance (Zafar & Rafiq, 2023; Malik et al., 2022). These loop holes prominently underscore the necessity of longitudinal, experimental studies that will quantify the effects of AI interventions on academic performance as well as pin pointing the precise contributions of soft-skills to the latter.

The city centers like Karachi have a mixed landscape. Private schools have tendencies to have means of AI-connected learning programs and personalized learning systems (Raza et al., 2021).

On the other hand, various schools, primarily public and semi-public ones, do not have stable online connectivity, as well as sufficient devices as the ability to implement AI-based group tasks that involve a three-way i-communication (Qureshi et al., 2020). These types of structural inequity may dramatically affect the trustworthiness and performance of wings based educational methods, particularly on tasks that require synchronized connections with the students (Memon et al., 2022).

Another determinant that is critical is teacher readiness. Not only should educators understand how AI technology works, but they should also create a learning experience in which AI is used to exploit its affordances to communicate with one another and solve problems (Sikander et al., 2021). The research of the attitude of Karachi teachers also indicates that there is a conflict between the interest in the possibilities of AI in teaching and the fear of insufficient training and the lack of resources (Ahmed et al., 2022).

Overall, the complex influence of AI on communication and collaboration on the secondary school level is still in its infancy. To be able to unveil positive and negative impacts of AI on various Pakistani educational settings, future studies must utilize the rigorous experimental designs, longitudinal follow-ups, and mixed-methodology to separate the possible advantages of AI usage/implementation and its unintended social impact.

The current body of literature on AI-facilitated learning in secondary school education is full of suppositions and abstract theory but highly lacking in high-fidel empirical data that would show an objective increase in soft skills associated with the communicative and collaboration skills of learners in Karachi. Although some studies reviewed in this paper have analyzed the perceptions of students towards AI tools (e.g. ¯Khan¯Fiaz, 2021), their academic performance alone (Rehman et al., 2020), or their degree of propensity to transition to higher-education (Saeed and Ali, 2019), none of them used controlled experimental designs to measure pre- and post-intervention results in collaborative and communicative competence. This gap in evidence warrants a study that is experimental and, therefore, capable of measuring the effect of AI-based instructional activities on these skills in a real-world setting, that is, a Pakistani secondary school setting.

The current project is aimed at addressing this gap by introducing a pre-post experimental study that will evaluate how AI-based teaching modules impact the capacity of students in secondary-schools to express themselves persuasively and cooperate in groups. The validated performance measures will be used to collect quantitative data before and after the intervention (e.g., the Communication and Collaboration Scale for Adolescents, Communication Scale; Ahmed and Nasir, 2018). The evidence obtained will give a concrete foundation to educators, administrators, and policymakers on how AI tools can be incorporated strategically to help in inculcation of the necessary soft-skills.

The work addresses the needs of the context of Pakistan secondary education system as well as indicates the alignment of the research with the global research regarding the use of AI in education. The study focuses on communication and collaboration which are the skills that can be listed as essential in a new global and knowledge-based economy (Trilling and Fadel, 2009; Partnership for 21 st Skills, 2019) and provides the data-driven evidence concerning the impact of AI on the socio-cognitive experiences of students. The study also presents a subtle observation regarding the power of the AI to support the purposeful interaction and joint process of learning with the secondary-school level in the framework of the strict experimental research method and situational sensitivity.

**The presentation of AI in the Realm of Education and Soft Skills**.

Artificial Intelligence is transforming education on a global level and not confined to automated evaluation and personalization to foster non-material skills like communication and collaboration (Luckin et al., 2016; Holmes et al., 2019). With the changing orientation of educational systems to the needs of a knowledge

economy, the ability to participate in productive conversation, work together in solving problems, and act effectively in teams has become one of the most important learning outcomes among students (Trilling and Fadel, 2009). As a result, researchers have explored the possibilities of facilitating student interactions through an AI-based platform (adaptive discussion forums, intelligent tutoring systems, and collaborative virtual environments) when it comes to training communicative and collaborative skills (Baker'NTV, 2014; Declercqet al., 2020). These affordances are consistent with skill frameworks of the 21st century, where teamwork and communication are the main focus of the educational agenda (Partnership for 21 st Skills, 2019).

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**Implication of AI on Communication Skills.**

The exchange of meaning is a concept of communication that is integrated in speech, written form, listening and interpretation of symbolic media (Higgins et al., 2005). In traditional classrooms, such skills are achieved by means of face-to-face conversations and teamwork between the teachers and the students. However, high enrolments, reduced instruction time, as well as imbalanced involvement often limit significant communicative interaction (Higginset al., 2005).

Such contexts can involve the use of artificial-intelligence (AI) to be facilitators and provide feedback. As an example, intelligent chat systems and chat boards with AI will stimulate students to develop their ideas further, share more in-depth thoughts, and assess responses of peers (Zawacki—Richter et al., 2019). The adaptive AI agents help track the input of conversations and present prompts to facilitate a more in-depth discussion and, thus, a less heavy cognitive burden and a more fair and equal contribution (Zawacki-, Richter-, et.al., 2019).

There is empirical evidence that demonstrates that AI guided learning has a positive effect on

communicative outcomes. According to a quasi-experimental study, Zhang, Wang, and Li (2024) found out that students engaged in AI-mediated collaborative learning activities have more communication fluency and clarity gains than students whose instructions were presented through the traditional approach. The results of these researchers are also similar as Lee, Kim, Park, and Choi (2025) stated that the use of AI in moderating problem-solving in the context of group work improved student verbal reasoning and expressive ability (Lee et al., 2025).

Although such positive outcomes have been noted, other researchers warn that AI can reduce face-to-face communication when implemented as a substitute, but not supplement, of teacher communication (Frey and ʊ Osborne, 2020). This observation emphasizes the importance of instructional design that will entail pedagogical mediation and organization of tasks, which will maximise communicative interaction (Frey and Osborne, 2020).

**Implementation of AI in Teamwork.**

Teamwork is described as a cooperative effort by people in achieving a common goal requiring organisation, negotiation, as well as support towards one another (Dillenbourg, 1999). Conventional research on collaborative-learnings still previews peer interaction, problem sharing as well as joint discussion as the main driving forces of collaborative competence (Dillenbourg, 1999).

As part of teamwork, AI has been embraced to improve the coordination and interdependence amongst learners. There is still some evidence to support the idea of adaptive group-formation algorithms that balance teams based on strengths of learners to allow equal contributions and prevent bottlenecks in coordination (Guerra et al., 2021). Artificial intelligence-based project platforms allow maintaining track of workload distribution, identifying communication failures, and proposing more efficient coordination options (Guerra et al., 2021).

Another recent survey study by Hasan, Nasreen, and Rasul (2025) related to university courses and identified that the early introduction of AI in the instructional cycle raised the level of shared tasks, group reflection and knowledge co-construction. The participants indicated that they had a more accurate vision of the team roles and were able to synthesize different points of view, which were crucial elements of effective collaboration (Hasan, et al., 2025).

However, collaborative education has an affective and social aspect, as well as trust, interdependence, and social regulation (Roschelle and Teasley, 1995). Some of these aspects may be hard to develop unless facilitated consciously with the use of AI devices (Roschelle and Teasley, 1995). As such, the literature is growing to recommend a moderate involvement of AI into tasks designed by teachers, such that the technology supplements instead of replaces the human interaction (Roschelle and Teasley, 1995).

**Making AI and Pedagogical Structures Happen Together**.

The power of artificial-intelligence (AI) interventions in communication-and-collaboration (C-a-C) environments lies in the fact that these interventions should be part of an instructional design. AI is not meant to be an autonomous enabler but more of an enhancing resource, it needs to be integrated as a part of the structured sequences of learning, utilizing the teaching skills and collaboration between peers (Tomas and Martinez, 2022). As an example, AI-based constructive feedback can facilitate less frequent grading tasks, thus, allowing instructors to release the sustained instructive discourse and allowing students to unfold the discussion-related topics more thoroughly (Luckin, Holmes, Griffiths, and Forcier, 2016; Chen, 2020). To add, AI systems are able to track group conversation in real-time, and define students who need specific assistance, thereby enhancing the quality of the collaboration overall (Zhao and Wang, 2023).

The desire to pair AI affordances and instructional design that can be task-based usually has stronger results when conducted through empirical studies. Zhang, Wang, and Liu (2024) found statistically significant better communication and collaboration metrics using AI-mediated collaborative tasks with teacher scaffolding, than using AI tasks applied on their own. This

synergistic association has been supported by further studies that reveal that the teacher-AI partnership accents learning benefits and enhances peer interaction (Huang and Lee, 2021).

**Gaps in the Literature**

Although the research into AI has proliferated rapidly in educational settings, there are still a number of gaps, especially in secondary education and under-resource setting. Diffusion to secondary schools in developing countries with constraints on infrastructure, lack of teacher preparedness and inequities is scarcely evidence-based because most of the experimental work is done in tertiary or well-equipped settings (Holmes, Bialik, and Fadel, 2019; Kumar and Singhal, 2020). Research on attitude towards technology has been mostly carried out in Pakistan, and little has objectively evaluated how communication or collaboration changes with AI interventions (Ahmed and Raza, 2024). Also, most studies do not use rigorous pre-post designs that allow causal inferences hence the necessity to adopt experimental research that would assess the effects of AI-based learning on teamwork and discussion among students in Sindh and Karachi.

**Theoretical Framework**

The theoretical foundation of this research is deeply rooted in modern educational technology theory and the principles of constructivist learning, according to which interactive and AI-based learning settings develop the necessary efficiency of the 21s-century learner with the necessary key competencies.

TPACK framework explains the interstitial knowledge that teachers have to have to be able to incorporate technology in pedagogy and content area. During the pre-observation phase, the framework will capture the level of knowledge students have about collaboration and communication at the time they are assigned with the level of the educators with regard to the skills of synchronizing both content, pedagogy and technology to deliver the comprehensive learning outcome.

The educational environment is viewed through the lens of Social Constructivism by Vygotsky in which the importance of collaborative learning, scaffolding, and Zone of Proximal Development (ZPD) is stressed. In this paradigm AI technologies serve as cognitive assistants and provide customized feedback and personalized contents that can empower learners to outperform their abilities.

In the post observation stage, the framework measures the changes in TPACK knowledge and classroom dynamics such as student interaction, self-directed learning, and scaffolded understanding, which are in agreement with the Vygotskyian principles. Also, the framework questions the role of AI in the 21st-century acquisition of skills by providing the interactive and data-driven cognitive experiences that are adjusted to the specifics of the individual learner. The combination of these theoretical approaches will result in the research that would provide a thorough evaluation of the characteristics of the pedagogical approaches and the outcomes of student learning, so that the impact of AI tools is going to be examined through the prism of instructional and developmental perspectives.

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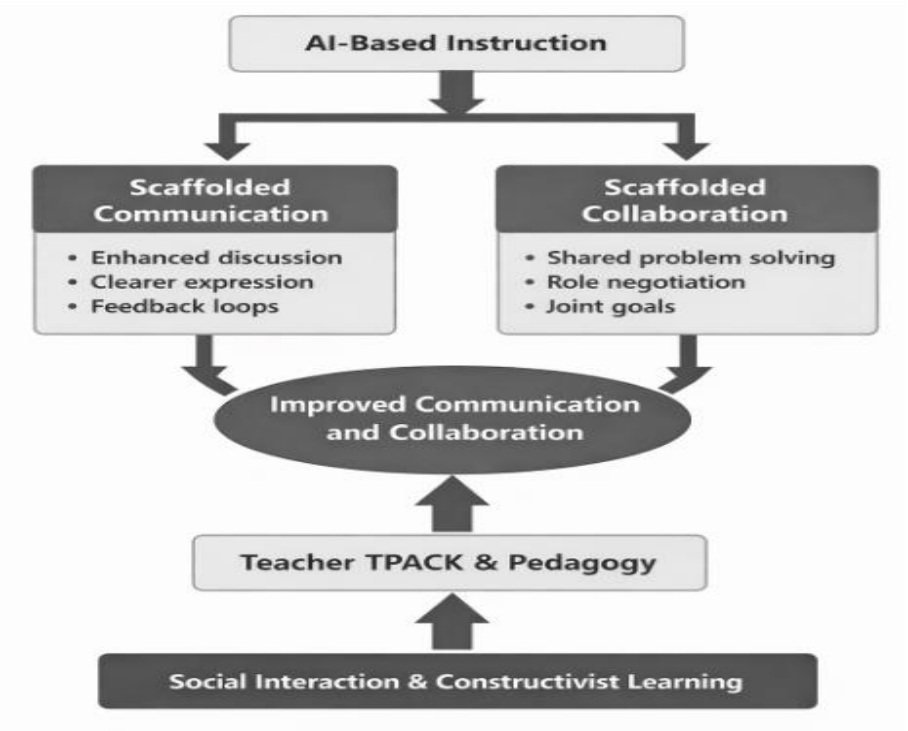



**Figure: 1**

This theoretical framework provides an orderly process of understanding the impact of AI tools on the improvement of the collaboration and communication among high-school students in Karachi. Through the examination of the associations between AI application and the collaborative abilities of students, this research paper will shed light on the place of AI in the 21st-century education in a subtle manner.

The hypothesis proposed in the above study is as below:

**$H_1$**: The incorporation of AI-tools has an effect on Learner's Communication Skills between the pre-post analyses.

**$H_2$**: The use of AI tools has an effect on student's collaboration skills reflected in changes from pre analysis and post observation.

## Research Methodology

A quantitative and experimental investigation was been made. Most of the past related scholarly studies that utilize inductive based research have investigated the potential to use artificial intelligence to facilitate and increase the use of soft skills in academic development not only in Karachi, Pakistan, but also in various other contexts of the world. As a result, the current research assumed a different methodology regarding this laid out area of study.

The study of experimental design offers a stringent methodology in order to investigate multifaceted effect. Through planning, carrying out and appraisal of experimental processes, investigators are able to control the influence of variables, reduce biases, and create reliable and meaningful data. Experimental design is the only design that is best applied in establishing causality; through the manipulation of an independent variable and the effect of this variable in either a dependent variable through controlled conditions, researchers are capable of making inferences about causal connections. A solid experimental design allows full testing of the hypothesis using statistical methods to establish that the found data are statistically significant or can be explained by chance (Creswell and Creswell, 2018).

## Target Population

Under the scrutiny of an actual experimental design analysis, it is the population of students under which the findings will in turn be extrapolated. The population group will include

high-school students of a lower-tier school located in Karachi, where digital tools are not incorporated and there is no development of basic life skills.

**Sample**

The sampling was conducted by random, which resulted in a sample of 40 high-school students of one of the private schools that were known to have a skills gap and were chosen to study. The effect of randomization is that it will minimize bias where all the members of the target population are given equal chances to participate. Fewer subjects are needed where subjects undergo all experimental conditions. The number of 40 participants was enough to perform a preliminary analysis and take the same amount to the post-analysis after implementing AI-related tools. The 40 sample size is also sufficient to identify moderate effects in within-subjects pre-post designs (Cohen, 1988) as well as work within the limits of school-based research (Whitehead et al., 2016), yet it is higher than the typically recommended 30 sample size in quantitative research (Fraenkel and Wallen, 2009).

The instrument will be applied both at the baseline and after the AI-based intervention to have the possibility to test the pre- and post-implementation by the means of analyzing the pre and post perceptions of 21 st century abilities in students. None of the fundamental changes was done to the original structure and wordings of the instruments and the consistency and validity guaranteed by the original writers was compromised. Slight linguistic changes have been brought in to make sure that the context is comprehensible to the students in the Karachi learning environment.

Instrument Reliability: Reliability refers to the permanence and steadiness of the tool with time. The internal consistencies as reported by the original developers were high with Cronbach 0.749 to 0.876 coefficients varying among four subscales. In order to confirm reliability in the adapted version, Cronbachs 6 values were as follows:

- Collaboration: 0.816
- Communication: 0.717

These values support the satisfactory internal consistency and prove the reliability of the used adapted instrument in the evaluation of 21 st -century competences of high-school students at Karachi.

**Statistical Model of the Study**

With 40 students in a sample and most P-values of normality tests (Shapiro-Wilk and Kolmogorov-Smirnov) of less than 0.05, the breach of the assumptions of normal distribution, non-parametric means, have been considered the right methods. Therefore, the Wilcoxon Signed-Rank Test was used to analyze statistical significance of differences in pre-observation and post-analysis score of all 4C variables.

- AI-based implementation and monitoring of instruction (about two months)
- Pre test and post test scores
- Statistical Test: Wilcoxon Signed-Rank Test (non-parametric)
- Significance Level: $\alpha = 0.05$
- Software: IBM SPSS statistics (version X)

**Descriptive statistics**

- Gender: The sample consisted of 19 boys and 21 girls, which made it possible to afford equal consideration to the impact of AI tools by gender.
- Grade Level: The participants were enrolled in the Grades 9 and 10 which guaranteed a homogeneity in the educational level.
- Age: The age of the participants extended between 14 and 16 years.

**Wilcoxon Signed-Rank Test**
**Table: 1**

***Wilcoxon Signed-Rank Test Ranks for Pre- and Post-Test Scores***

| Construct | Rank Type | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| **Communication** | Negative | 5[a] | 12.8 | 64 |
| | Positive | 35[b] | 21.6 | 756 |
| | Ties | 0[c] | | |
| **Collaboration** | Negative | 0[a] | 0 | 0 |
| | Positive | 40[b] | 20.5 | 820 |
| | Ties | 0[c] | | |

a. Post analysis < Pre-observation
b. Post analysis > Pre-observation
c. Post analysis = Pre-observation

**Communication**
A marked positive trend was observed, with 35 respondents improving their post-test scores (mean rank = **21.60**), whereas only 5 participants had decreased scores (mean rank = **12.80**). No ties were noted. These findings indicate a significant improvement in communication skills post-intervention phase.

**Collaboration**
The outcome for collaboration were particularly remarkable: all 40 participants showed growth in post-test scores, with no negative ranks or ties. The mean rank was **20.50** for all positive ranks. This result firmly supports the effectiveness of the intervention in strengthens collaboration among participants.

***Wilcoxon Signed Rank Test Statistics:***

| | Communication | Collaboration |
|---|---|---|
| Z | -4.651[b] | -5.517[b] |
| Asymp. Sig. (2-tailed) | .000 | .000 |

b. Based on negative ranks.

**Table: 2**

For **communication**, the difference was extremely significant, $Z = -4.65$, $p < .001$, indicating notable increase in students' communication skills after the intervention.
Similarly, **collaboration** presented a statistically significant development, $Z = -5.52$, $p < .001$, with all respondents showing positive rank differences, illustrating the effectiveness of the intervention in encouraging collaborative competencies.
Comprehensively, the results show that the AI-based teaching method can tremendously improve the performance of students in teamwork and communication. The statistical tests validated both the hypotheses (H1-H2).

**Conclusion**
The current research validates the fact that by incorporating AI into a TPACK-based, socially constructivist model, one can support the needed competencies and thus allow the students to succeed in a more advanced and digitalized world. To enhance the outcome of future studies, it is essential that the mutual process of defining the relationship between technology, pedagogy, and social interaction should be researched to enhance educational results in a variety of learning situations.

**Limitations and Future Recommendations**

Future research should also undertake a bigger and more diverse sample based on diverse schools, cities, and educational backgrounds in Pakistan. This would promote the overall generalizability of the findings and make it possible to use stronger statistical measures, such as factor analysis and structural equation modelling (SEM). Longitudinal research designs would be advisable to get a clear picture of this study and the long-term influences of AI-incorporated interventions on the 4Cs.

Such researches may bring more profound findings on the impact of the long-term exposure to AI tools on the building of cognitive and relational abilities of students in the future. Integration of qualitative techniques, whether interviews, observation in the classroom or student reflection, with the quantitative analysis would yield a deeper insight into the how and why AI-driven instruction has an impact on academic achievement.

Despite the main aspect of this study being the 4Cs, future studies can consider the role of AI on other competencies like digital literacy, information competency, adaptability, or leadership to provide AI with a wider educational potential.

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