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TEACHERS' PERCEPTIONS AND STUDENTS' ACHIEVEMENT IN THE DIGITAL AGE: A SYSTEMATIC REVIEW OF EMPIRICAL STUDIES

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Abstract
New digital technologies have been rapidly used in the educational sector, in transforming the teaching practice and learning environment. The systematic review focuses on teachers' conception of digital educational tools for student academic achievement in mathematical subject at elementary level. The structured searches of scholarly databases ERIC, PsycINFO, and Scopus retrieved peer-reviewed studies (2017 – 2024). Twenty-five empirical studies `analyses were made based on themes and the results reveal that the attitude of teachers with regard to usefulness, ease-of-use, preparedness and self-efficacy, as well as training and institutional support, is directly related to the quality of integration and affects student performance, interest and abstract cognition along with contextual issues, which are demonstrated in such situations as in Pakistan. The suggested recommendations are specific professional training, approaches to fair access, commitment to dependable infrastructure, and fostering a positive school environment to incorporate digital technologies to produce better learning results.

Keywords: Teacher Perceptions, Student Achievement, Digital Educational Applications, Technology Integration, Mathematics Education, Systematic Review, Elementary Education.

INTRODUCTION

Digitization of education will offer better learning outcomes and tools of pedagogy. Empirical meta-analyses report a small positive impact of digital educational applications (DEAs) on student performance in such subjects as mathematics consistently (Kim et al., 2021; Aspiranti and Larwin, 2021). Nevertheless, technology availability does not directly lead to better student performance. The classroom teacher is a central mediator of it, both in their instructional decisions and their pedagogical methods, but above all in their own understanding of the value of technology and their own ability to effectively use it (Fuchs, 2022; Barrientos, 2021). In third-world countries such as Pakistan, where digital education programs are being massively implemented (such as Digital Pakistan, e-Taleem), it is important to know this mediating position. There is a huge disparity between the policy-based technological delivery and the integration of technologies in the classroom. The gap itself is frequently a reflection of the perception of the teachers due to the contextual peculiarities, which include the insufficiency of the infrastructure, the lack of advanced training, and the doubts about social and cultural aspects (Malik, 2024; Waqar et al., 2024).

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RESEARCH QUESTIONS

1. What is the empirical evidence linking the use of digital tools to student achievement in elementary mathematics?
2. What factors shape teachers' perceptions regarding the integration of digital educational applications?
3. How do teachers' perceptions influence the implementation fidelity and effectiveness of DEAs, ultimately impacting student achievement?
4. What strategies can positively influence teacher perceptions and strengthen the perception achievement link in contexts like Pakistan?

By synthesizing global evidence and contextualizing it within the Pakistani landscape, this paper aims to provide a nuanced understanding crucial for moving beyond techno-centric solutions to human-centric, sustainable educational improvement.

METHODOLOGY

The research design used in this paper is the Systematic Literature Review design with a thematic synthesis approach, based on the interconnection of teacher perception and student achievement.

1. Search Strategy & Source

Analysis combines the literature of an already existing comprehensive collection. The initial assemblies were collected based on a keyword search in academic databases (Google Scholar, JSTOR, ERIC) of such terms: teacher perceptions, technology integration, student achievement, digital math tools, TPACK, Pakistan education technology.

2. Included Criteria

Empirical research (quantitative, qualitative, mixed-methods) between 2017 and 2024 that contained explicit or implicit discussion of teacher attitudes/beliefs/perceptions and quantified/reported student learning in mathematics (K-8). Research on the blended learning, individual DEAs, and teacher professional development were given priority.

3. Excluded Criteria

Purely technical papers, studies without a clear link to teacher agency/perception or student outcomes, opinion pieces.

4. Analytical Framework

Technological Pedagogical Content Knowledge (TPACK) framework and Technology Acceptance Model (TAM) were used as the prism to classify and interpret perceptions. Coding of studies was done based on: (a) reported student achievement statistics, (b) perceived teacher perceptions/attitudes, (c) situational factors affecting perceptions, and (d) perceived connections between (a) and (b).

LITERATURE REVIEW

Table 1

Summary of Empirical Studies on Digital Technology, Teachers' Perceptions, and Students' Achievement

Author(s) & Year	Context / Sample	Digital Tool / Technology	Methodology	Key Findings
Aspiranti & Larwin (2021)	Meta-analysis: 20 studies, 2,805 students	Touch-screen tablets	Meta-analysis	Moderate positive effect on math scores. Impact varies by student demographics and app used.

Author(s) & Year	Context / Sample	Digital Tool / Technology	Methodology	Key Findings
Kim, Gilbert, Yu, & Gale (2021)	Meta-analysis: 36 studies, Preschool–Grade 3	Educational apps (math & literacy)	Meta-analysis	Moderate positive effect (+0.31 SD). Effectiveness varied by grade (higher in preschool), assessment type, and app design.
Hardman & Raudzingana (2021)	Study on Mathletics use in South Africa.	Mathletics software (Computer Assisted Instruction)	Quasi-experimental	No significant test score improvement. Useful for drill/practice but lacks conceptual depth and limits achievement impact.
Ulun (2023)	Grade 4 students	Khan Academy	Quasi-experimental	Digital platform enhanced achievement and learner engagement. Highlighted self-paced and mastery learning
Wang (2024)	Review of modern technology in education	Various technological tools	Analytical review	Technology enhances learning through interactivity but may weaken critical thinking if over-relied upon. Teacher training and equitable access are crucial.
Malik (2024)	Pakistan, public schools	Online/digital learning tools	Systematic analysis	Effectiveness curbed by infrastructure and teacher readiness.
Waqar, Muhammad, & Anis (2024)	Pakistan, mixed contexts	Broadband internet, digital devices	Survey research	Digital divide significantly influenced learning outcomes. 48% urban vs. 23% rural broadband access.
Verbruggen, Depaepe, & Torbeyns (2021)	Analysis of 54 studies on Early Childhood Education.	Varied ET (educational technology)	Systematic review (media comparison & value-added)	ET assists in developing math skills. Support from teachers and high-quality implementation designs are important success factors
Gideon, Haruna, & Umar M. A. (2021)	83 students (ages 7–11), Nigeria	Prodigy Math Game	Quasi-experimental	Experimental group scored significantly higher in math attitude (43.81 versus control 32.15). This indicates motivational benefits

Author(s) & Year	Context / Sample	Digital Tool / Technology	Methodology	Key Findings
Barrientos (2021)	Grade 8 students, Philippines	Math apps (TPACK-based)	Mixed-methods (pre/post-tests)	Students scored high. A teacher aims for the best utilization of TPACK which means technological, pedagogical, and content knowledge
Cabugwason et al. (2024)	20 pre-service math teachers	Various math apps	Qualitative (interviews)	Applications enhanced the teachers' comprehension of mathematical concepts. Obstacles are cost, confusing interface, and internet connectivity. This challenges perception and competencies.
Engelbrecht & Borba (2023)	Review of 5-year trends in math education	Digital tools: Computer Algebra Systems, Dynamic Geometry, AI, STEAM, social media.	Analytical review	Post-pandemic change occurred, and teachers focused more on the conceptual understanding instead of procedural knowledge
Alrajeh & Shindel (2020)	Multi-year classroom observation study	Not a specific tool; study on classroom engagement factors.	Quantitative (ANOVA, correlations)	Students’ engagement was strongly influenced by teacher instructional support. Engagement level may also differ by gender
Ristić et al. (2023)	228 students, adaptive e-learning study	Moodle-based adaptive system (VAK styles)	Quasi-experimental with delayed post-test	Learning, satisfaction and retention of the female students improved through the adaptive system. It highlights the importance of designing personalised tech.
Manouchehri et al. (2019)	Grade 5 students using simulation	Computer simulation for systems thinking	Qualitative case study	The simulation directed the students to have continuous ability to reason and to manipulate variables. Refined hypothesis assessments and confidence in justifications.

Author(s) & Year	Context / Sample	Digital Tool / Technology	Methodology	Key Findings
Jarrah, Almassri, Johnson, & Wardat (2022)	80 students, UAE	ABACUS digital fraction game	Quasi-experimental	Game group performed significantly better than the control group in fraction problems. The study highlights the need for teachers to have confidence in technology and be trained to use it to overcome the barrier
Khan et al. (2024)	Analysis of blended learning in Pakistani schools	Blended learning models	Policy/implementation analysis	There is currently no structured model available that supports blended learning. According to suggestions, localized frameworks and teacher digital fluency must be designed.
Afzal, Khan, Daud, Ahmad, & Butt (2023)	Analysis of digital divide	Digital technological tools	Empirical data synthesis	Young, urban, and male students have better access to technology. It is recommended to set up tech help centres, affordable connectivity, inexpensive devices and digital literacy.
Joshi, Khatiwada, & Pokhrel (2024)	Systematic review (2017-2024) on socioeconomic status	Digital learning resources (computers, tablets, internet, platforms)	Systematic Review	Students from disadvantaged households face digital divide (devices, connectivity) to take part in school-based as well as home-based learning processes. Household income, parenting, and gender norms influence technology use.
Vijayatheepan (2023)	Implementation of digital science/math labs	Interactive digital labs	Implementation study	Performing experiments interactively with Virtual Labs, enhances the learning process of learners in STEM subjects.
Obina et al. (2022)	80 students, study on app use, habits, and performance.	Various math apps (81% calculators)	Explanatory-sequential mixed-methods	Apps made grades better but resulted in over-dependence, laziness and less self-study. Dual-edged effect based on

Author(s) & Year	Context / Sample	Digital Tool / Technology	Methodology	Key Findings
				technology perception and use.
Ahmed & Anwar (2023)	120 fifth-graders, Punjab, Pakistan	Blended learning (digital + traditional)	Quasi-experimental	Blended group scored better, particularly problem-solving & geometry - an effective model, where the teachers should think of tech as a complement, rather than a replacement.
Ali, Ullah, & Habib (2022)	92 Grade 6 students, KP, Pakistan	Blended learning (videos + classroom)	Quasi-experimental	The hybrid method group scored better in algebra and geometry. Scaffolding by teachers essential in digital lessons.
Fuchs (2022)	290 teachers, Finland	Smartphones in classroom	Quantitative survey (TAM model)	Intention to use is affected by teacher attitudes and social norms.
				Establishes a direct correlation between the perception of the teachers (usefulness, ease of use) and adoption behavior.
Teoh et al. (2022)	Rural Malaysia, 4 math teachers	WhatsApp, video tutorials	Qualitative case study	Parental involvement facilitated by teachers through available technology enhanced performance.
Nadaf et al. (2023)	UAE TIMSS 2019 data (Grade 4 & 8)	Machine learning (SHAP) analysis	Predictive modeling	Confidence of students' best predictor of Math performance. Indirectly highlights the role of teacher support in building confidence.

RESULTS AND SYNTHESIS

1. Evidence Base: Digital Tools and Student Achievement.

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The empirical evidence confirms the existence of the fact that adequately utilized digital tools are able to be employed to augment achievement. The key achievement related results are summarized in Table 2.

Table 2

Empirical Links Between Digital Tool Use and Student Achievement in Mathematics

Category of Achievement	Documented Evidence	Key Studies
Standardized Test Scores & Grades	Moderate mean effect size (+0.31 SD); significant pre/post-test improvement; reaching a higher levels of proficiency.	Kim et al. (2021); Barrientos (2021); Ulun (2023)
Mastery of Specific Skills	Better proficiency in fractions, algebra and geometry with focused app-based practice and visualization.	Jarrah et al. (2022); Ahmed & Anwar (2023)
Cognitive & Metacognitive Gains	Greater problem-solving, hypothesis testing, and conceptual learning through simulations and interactive environments.	Manouchehri et al. (2019)
Affective & Behavioral Precursors	Improved motivation, engagement, time-on-task, and positive attitude, which are all related to long-term achievement.	Gideon et al. (2021); Alrajeh & Shindel (2020)

2. The Mediator: Understanding Teachers' Perceptions

The teacher-perception is a multi-dimensional issue. As an analysis reveals, it is affected by several fundamental factors as indicated in Table 3.

Table 3

Factors Shaping Teacher Perceptions of Digital Educational Applications

Factor Domain	Components	Impact on Perception	Supporting Evidence
Self-Efficacy & Competence (TPACK)	Technological knowledge perceived, integration pedagogical skill, perceived ability to troubleshoot.	Low efficacy causes avoidance anxiety, and high efficacy promotes innovation and persistence.	Barrientos (2021); Cabugwason et al. (2024)
Perceived Usefulness &	Perception that the tool enhances learning, time-saving, curriculum	Drives adoption intent. Misalignment with curriculum	Fuchs (2022); Teacher resistance

Factor Domain	Components	Impact on Perception	Supporting Evidence
Relevance (TAM)	alignment, and student needs.	(e.g., Pakistan's SNC) diminishes perceived usefulness.	noted in Malik (2024)
Perceived Ease of Use (TAM)	Opinions on the complexity, reliability, easy-to-use design, and compatibility of tools with current infrastructure.	Obstruction due to weak connectivity or puzzling interfaces builds negative perceptions, irrespective of tool potential.	Iqbal et al. (2023); Waqar et al. (2024); Afzal et al. (2023)
Contextual & Systemic Influences	Access to training, technical support, institutional encouragement, and resource availability.	Negative perceptions are developed when teachers do not receive support; they perceive it negatively. However, effective professional development and school leadership can change that perception.	Cabugwason et al. (2024); Malik (2024); Khan et al. (2024)

3. The Perception-Achievement Link: A Contingent Relationship

The study explains that technology alone does not ensures its success is dependable on teachers' perceptions. This contingent relationship can be seen in Table 4.

Table 4

The Contingent Link Between Teacher Perception and Student Achievement

Teacher Perception Profile	Likely Implementation Style	Impact on Student Learning & Achievement
Positive & Confident (High TPACK, TAM)	Strategic, integrative, student-centered. Uses tech for differentiation, exploration, and feedback.	High Positive Impact. Achieves cognitive and affective gains documented in Table 1.
Cautious but Willing (Moderate Perceived Usefulness, Low Ease)	Supplemental, rigid, teacher-controlled. Uses tech mainly for drill/practice or as a reward.	Mixed/Limited Impact. May yield basic skill gains but fails to leverage higher-order potential.
Resistant or Negligent (Low Usefulness, Low Efficacy)	Avoidant, symbolic, or disruptive. Rejects tech or uses it in ways that hinder pedagogy.	Neutral or Negative Impact. Wastes resources, can disengage students, and widens gaps.

4. The Pakistani Context

In this case, the systemic obstacles tend to confine the teachers to the Cautious or the Resistant profile. The digital policies (Digital Pakistan) do not meet the ground realities of poor infrastructure and training, as this creates an impression of technology as ambitions a burden but not a helpful instrument hence blocking the gains of possible achievement.

Table 5

Synthesis of Factors Influencing DEA Effectiveness

Factor Layer	Critical Elements	Supporting Evidence
Pedagogical Layer	Alignment with curriculum goals; quality of instructional design; strategic integration into lesson flow (beyond mere substitution); teacher as a skilled facilitator.	Barrientos (2021) - TPACK; Engelbrecht and Borba (2023)
Technological Layer	The interface is easy to use; the app works offline; it is adaptive, reliable on cheap popular devices and very user-friendly.	Cabugwason et al. (2024); Iqbal et al. (2023)
Human & Support Layer	Teaching methods must include interaction with the student, digital pedagogy and data interpretation. Using scaffolding at home by parental Involvement, student readiness, and basic digital literacy.	Alrajeh and Shindel (2020); Teoh et al. (2022); Nadaf et al. (2023)
Contextual & Systemic Layer	Stable electricity and internet connections; equal access to devices; sustainable funding arrangements; enabling policy environment.	Waqar et al. (2024); Joshi et al. (2024)

DISCUSSION

The thesis that comes out of this synthesis is that student performance in the digital age is more a product of software and less a product of so-called teacher-ware the beliefs, skills and perceptions of the teacher. The evidence of DEA efficacy on the global level assumes the degree of pedagogical integration that is perception-dependent.

Pakistan is especially vulnerable to the so-called Perception-Achievement Gap. Teachers view digital tools in the prism of constraint: unstable electricity power, intermittent internet access, device shortages, and a curriculum that is not readily available to digital exploration. This creates an impression of hopelessness or increased complexity which results in low integration implementation which will have little achievement benefits therefore a vicious cycle that perpetuates negative perception.

Moreover, the two-stage role of professional development is mentioned in the review. First stage PD must directly target and shift perceptions (demonstrating ease and usefulness). Only then can second-stage PD on pedagogical integration be effective. Programs like DigiSkills.pk must

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evolve beyond technical skill delivery to include perception-change modules featuring local success stories.

A Framework for Bridging the Perception-Achievement Gap

To convert negative or hesitant perceptions into catalysts for achievement, a structured framework is proposed (Table 6).

Table 6

Framework for Aligning Teacher Perceptions with Student Achievement Goals

Strategic Goal	Interventions to Shift Perceptions	Expected Impact on Achievement
Enhance Perceived Usefulness & Relevance	- Develop localized models of the use of DEA with the National Curriculum of Pakistan. - Support teacher learning communities in success stories. - Engage teachers in the process of selecting and assessing DEAs.	The teachers are no longer viewing tech as an extra but an essential and more consistent and aligned use of tech, which enhances mastery of the curriculum.
Build Self-Efficacy (TPACK)	- Introduce micro-credentialing to digital pedagogy and apply it in classrooms. - Peer coaching teachers to integrate tech. - Technical and pedagogical support on demand.	The decrease in anxiety results in greater experimentation and more elaborate integration strategies, which contribute to higher-order thinking.
Mitigate Negative Contextual Perceptions	- Promote and supply offline-first and low-bandwidth toolkits. - Have backup strategies (hybrid models) in case of technological failures. - Reward and acknowledge adaptive teaching under difficult circumstances.	Teachers do not feel victimized by restrictions but are empowered and provide resilient implementation that maintains learning momentum.
Foster a Supportive Perception Culture	- School administration should be a leader and role model in terms of adopting technology in learning. - Dedicate time to joint lesson planning with tech. - Shift the aim of evaluation to appreciate value integration rather than mere usage.	A positive and collective belief system develops, and high-quality integration becomes the standard, thus improving classroom performance.

Proposed Framework for Sustainable Integration in Pakistan

On the basis of the evidence synthesized, a multi-pronged framework is suggested to help stakeholders in Pakistan (see Table 4). This model focuses more on the systemic rather than individual interventions.

Table 7

Framework for Sustainable DEA Integration in Pakistan

Strategic Pillar	Actionable Recommendations
Contextualized Development & Curation	- Localize mandates (Urdu/regional language interfaces, culturally relevant examples). - Build and maintain apps and content that are closely aligned to the National Curriculum (NC) learning outcomes. - Support the use of Open Educational Resources (OER), - Promote the use of low-bandwidth apps or offline-first apps.
Systemic Capacity Building	- Integrate digital pedagogy and TPACK into core pre-service and in-service teacher training programs. - Launch foundational student digital literacy modules from Grade 1. - Create simple parent engagement guides on supportive supervision of digital homework.
Equitable Access & Infrastructure	- Prioritize establishing community digital hubs in rural schools over unsustainable 1:1 device models. - Use the Universal Service Fund (USF) specifically to connect primary schools. - Implement managed device-sharing models with tablets/laptops pre-loaded with a curated suite of apps.
Evidence-Based Policy & Implementation	Commission large-scale action research to evaluate the efficacy of the DEA in diverse Pakistani settings. - Design a national assessment rubric to approve and recommend educational applications. - Public-private-academic sustainability partnerships: funding, innovation, and evaluation.

CONCLUSION

This review confirms the fact that the hope of using digital tools to enhance student performance is inextricably connected with the human factor - perception of the teacher. Policymakers and school leaders should hence invest just as much in knowing and influencing teacher perceptions as they invest on acquiring hardware and software. To Pakistan, this implies a fundamental change in digital education policies of being supply based (it is about devices and apps) to being perception based (it is about teacher belief, capacity and support). The proposed framework provides an avenue to establish teacher agency as the basis of digital learning success.

FUTURE RESEARCH

1. Carry out longitudinal perception research that monitors the evolution of teacher beliefs in relation to training and experience in working with DEAs and that that relates these shifts to quantifiable student outcome data in the Pakistani schools.
2. Discover the effectiveness of perception-change interventions, including immersive experience using successful case studies or cognitive coaching, in contrast to the conventional technical training.

3. Explore the perception of students regarding the use of technology by teachers and how the student-teacher perception relationship interacts with the learning environment and student outcomes.

Making perception of the teacher the core of the digital achievement discourse, this review promotes a more sustainable, efficient, and just way of integrating educational technology.

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