

Trends of Using Low-Cost Technologies by Public Schools in Karachi: A Case Study

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Abstract

Despite limited educational resources, public school teachers in Pakistan are increasingly utilizing affordable technologies to improve their instructional methods. This study aims to investigate the trends (here, trends refer to patterns or directions of change) in the use of different types of technologies in public schools, as well as the difficulties educators face when integrating technology into the classroom, and to provide immediate solutions to overcome these challenges. This study will be exploratory. The methodology used for this study is a qualitative approach. The present study will employ the phenomenological method. The findings show that trends in teaching underwent rapid changes after the COVID pandemic. -19, teachers primarily used kinesthetic learning methods, such as role-play, charts, and 3D models. Now, teachers are shifting to technology, but they are utilizing low-cost technologies, including mobile devices, tablets, microphones, social media, open-source software, and mobile applications. Mobile phones were used for assessment and assignments. These technological tools have been successfully integrated into classroom instruction. The integration of technologies in educational settings has significantly enhanced the process of personalized learning. It has provided students with improved access to educational resources, facilitated more opportunities for practice and feedback, and contributed to the development of essential skills. These trends suggest that, with appropriate government financial support, teacher training and incentives can improve educational outcomes in resource-limited settings. This highlights the need for targeted investment in teacher training, workshops, and improvements to curriculum and infrastructure.

Keywords: Technological Trends; Low-cost Technology; Social Media.

Introduction

In the current era, technology has become an integral part of our lives in many ways, including in the field of education. In this fast-paced and constantly evolving world, it has become apparent that today's students need to acquire the ability to think critically and solve complex and ambiguous problems. Research has shown that students perform better in all subjects when they are engaged with technology in the classroom (Wenglinisky, 1998; Francis, 2017; Dyhrkopp, 2021). This is essential for them to prosper in their future work and living environment (Ventura et al., 2017). Besides students, teachers also benefit from teaching and want to utilize technology efficiently and

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effectively to enhance their instruction. In Kenya, English teachers use a Facebook group to address students' queries and foster social connections (Evans, 2021).

According to several researchers (Wenglinsky, 1998; Schindler et al., 2017; Harris, 2016), students can achieve higher scores by using computers to apply higher-order skills, such as solving simulations, rather than relying on drills and practice exercises. One of the main challenges facing educators today is that many students are naturally curious about new things and eager to learn. This is especially true for those born in the digital era, who are constantly exposed to new technologies. These students are often referred to as digital natives, a term coined by Prensky (2001) and later defined by Lashari et al. (2021).

Educational Technology (EdTech) is a broad field that encompasses multiple areas of education and is integrated into our education system to facilitate and enhance the teaching and learning process. "EdTech", which stands for Educational Technology, provides many advantages in the field of education (Coflan & Kaye, 2020; Rodriguez-Segura, 2020; Farhat, 2023). Educational technology, or EdTech, enhances learning experiences through multimedia, gaming, and simulation tools (Kikot, 2013; Samah et al., 2023; Lashari & Umrani, 2023). Interactive mediums engage students and facilitate communication between teachers and parents, fostering a collaborative educational environment with more profound understanding and retention of concepts.

Cost-effective technology refers to solutions that offer a function or benefit relative to their cost (Cotton et al., 2011; Imran et al., 2022). It involves maximizing the value derived from technological investments while minimizing expenses. This can be achieved through various means, such as leveraging open-source software and utilizing scalable infrastructure (Du 2022; Lashari & Umrani, 2023). By using efficient manufacturing processes and adopting sustainable practices, businesses can lower their long-term expenses (Govindan et al., 2020; Fayaz et al., 2023).

Statement of the Problem

This study aims to investigate the challenges educators face when integrating technology into the classroom and to provide immediate solutions to address these issues. First, I examined the various types of technology that educators use, including cost-effective options. Next, I identified the specific challenges educators encounter when implementing technology in their teaching. Technology has become a vital tool in modern education, enhancing teaching methods and improving student learning experiences (Bond & Bedenlier, 2019). However, public school teachers often face financial and resource constraints that limit their access to expensive educational technologies. In Pakistan, it has been noticed that there is a lack of emphasis on educational technologies (Ellahi, 2018) and social media, especially in Public Schools. Both students and teachers lack the necessary foundation to use these tools effectively and efficiently (Johnson et al., 2016; Lindell, 2022; Amara et al., 2016). It is crucial to comprehend how emerging digital technologies can enhance students' engagement, interest, academic performance, and retention in various study areas (Pinto, 2020). Therefore, conducting thorough research is essential to determine the most effective ways to integrate these technologies into teaching and learning activities.

In underprivileged educational settings, the lack of resources often hinders the delivery of quality education (Pal, 2020). In Pakistan, we are facing challenges in education, but the main issue I understand is the integration of technology in public school classrooms. There are numerous hurdles, such as budget constraints, a shortage of trained teachers, and socioeconomic issues

(Ahmed, 2014). The solution is to introduce low-cost technology in our public schools that is suitable for remote and marginalized areas (Subramaniam, 2017; Zubairi et al., 2021).

Research Objectives

- To explore the trends of using low-cost technologies by public schools in Karachi.
- To identify the challenges public school teachers face while using low-cost technologies.

Research Questions

- What are the trends of using low-cost technologies by public schools in Karachi?
- What are the challenges faced by teachers when using low-cost technologies in public schools in Karachi?

Scope of the Study

This research aims to help educators identify low-cost technology and explore methods for its implementation in the classroom. Additionally, it seeks to investigate the challenges faced by educators when implementing technology in schools. In disadvantaged countries like Pakistan, where resources are scarce, the primary solution is to prioritize cost-effective technology (Ahmed, 2014). Educators can enhance their curriculum by utilizing low-cost technologies, including interactive whiteboards, tablets, and e-books. They can also use platforms such as podcasts and vlogs to deliver lectures, rather than investing in expensive textbooks (Zhang, 2015).

This research enables researchers to explore the trends of utilizing low-cost technologies in public schools, thereby enriching their perspective. With the help of online forums, email messaging apps, and social media, teachers can now easily communicate with parents and other educators, share resources, and collaborate with students (Kajamma, 2020).

Literature Review

Technology can be defined as the Utilization of scientific knowledge for practical purposes or applications. It involves applying scientific principles to modify the world in which we live. Technology is also used to advance industries or other human constructions by utilizing scientific principles (Herschbach, 1995). The term 'Science' refers to the capability of generating solutions in a particular problem domain. The best definition of technology is the transformation of techniques, instruments, and machines created by humans. Technology enables humans to study the physical elements (climate, resources) present in their lives and to develop them (Kamp, 2019; Imran et al., 2022). Open educational resources (OERs) promote the reuse and repurposing of materials to reduce development time, minimize duplication of work, and tailor materials to be more specific and relevant to learners.

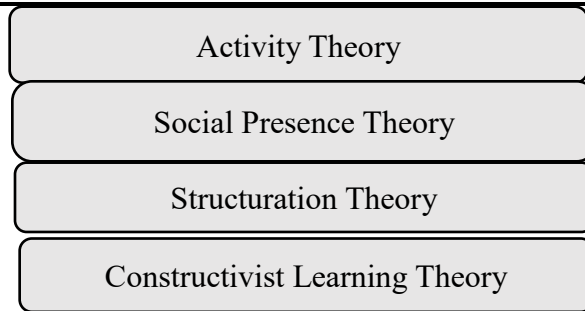
Additionally, social media facilitates access to user-generated content. The world's top 113 universities utilized YouTube for 80% of their formal and informal learning activities (UNESCO Gem Report, 2023). In the past, various technologies have been employed in classrooms. Our ancestors used lanterns, candles, and oil lamps, while blackboards were used to enhance the teaching experience. Additionally, overhead projectors were employed during World War 2 for mission briefings. The introduction of handheld calculators revolutionized our lives, and interactive whiteboards further advanced classroom technology, providing students with access to digital textbooks, cloud-based tools, and personal devices (Firmin, 2013).

In the 20th century, numerous innovations in physics occurred. The discovery of nuclear fission led to the development of atomic weapons and nuclear power. The invention of vacuum tubes led

to the development of analog computers, which were very expensive and large enough to fill a room, such as ENIAC. Later, the invention of transistors in 1947 changed the appearance and efficiency of computers, making them smaller and increasing their memory capacity. Moreover, the invention of microprocessors completely transformed computers, affecting their size, efficiency, price, security, and memory, ultimately altering the lifestyle of human beings. In modern times, the term "technology" refers to the use and creation of technological tools, as well as their interaction with society, nature, and the environment. It involves transforming scientific knowledge into products, services, processes, and organizational structures (Subramaniam, 2017; Abbasi et al., 2019; Lashari & Umrani, 2023). The significance of science and technology in modern times is evident in their rapid advancement (Tabassum, 2020). In this century, we have witnessed numerous inventions, including smartphones, cars, social media, and autonomous vehicles.

Low-cost technology refers to the development and use of affordable technological solutions, particularly in rural areas where resources are scarce or for disadvantaged populations (Cappola, 2020; Refer, 2017). Cost-effective technologies aim to provide functionalities similar to those of their more expensive counterparts at a lower cost. The concept of low-cost technology encompasses several areas, including healthcare, education, agriculture, and infrastructure (Cotton, 2011; Abbasi et al., 2019). In the healthcare sector, low-cost technologies may include affordable medical devices, diagnostic tools, and telemedicine solutions, as well as space-saving items that enable mobile healthcare delivery in rural or remote areas (Towse, 2018; DePasse, 2016; Goodman, 2014). Low-cost technologies, including e-learning platforms, open educational resources (OER), and inexpensive computing devices, rather than expensive books, aim to improve access to quality education for learners in marginalized communities (Baker, 2019; Cappola, 2020). Agricultural technologies, such as low-cost irrigation systems, precision farming tools, and mobile-based advisory services, can improve the livelihoods of smallholder farmers and increase agricultural productivity (Sissoko, 2022; Imran et al., 2022). Affordable technology has some key characteristics that make it suitable for resource-limited settings and contribute to socioeconomic growth and empowerment. These characteristics include simplicity, scalability, adaptability, and sustainability. Additionally, low-cost technology prioritizes community involvement and capacity building to promote inclusive growth.

Today's younger generation has grown accustomed to having technology constantly accessible. The popularity of social media applications and websites has piqued the interest of children. Additionally, the excessive use of cell phones, laptops, computers, and gaming devices can lead to hypertension in children (Carsten, 2021). Learners will be able to acquire new information more efficiently. They will have sufficient time to articulate their beliefs and engage in both online and offline discussions, and they will access educational resources at their own pace (Mahini, 2012; Salman et al., 2023). With technology, students learn quickly and easily. However, learners require support from parents, friends, coaches, and others. Information and communication technology (ICT) has been utilized in education for over 100 years, beginning with the widespread adoption of radio in the 1920s. Over the past 40 years, the technology industry has focused on developing and distributing educational content, learning management systems, language applications, augmented and virtual reality tools, as well as personalized tutoring and testing (UNESCO, 2023).

Figure 1: Theories of Technology

This theoretical framework combines four key theories—activity theory, constructivist theory, structuration theory, and social presence theory—to analyze the adoption and impact of low-cost technologies in public schools in Karachi. Each theory highlights different aspects of this issue: activity theory focuses on technology as a mediating tool within educational systems. Social presence theory examines how low-cost tools facilitate engagement in resource-constrained environments. Structuration theory explores the relationship between school structures and teacher practices. Constructivist Theory emphasizes student-centered learning enabled by technology.

Activity Theory

Activity Theory encompasses various social science theories and research, originating from the Soviet psychological theory of activity developed by Lev Vygotsky in the 1930s. It was later promoted and popularized by Alexei Leontiev and Sergei Rubinstein. Activity theory assumes a three-dimensional framework with the teacher at the center of the activity system, exerting power and control to balance the components essential for effective learning (Cowan & Butler, 2013). The Activity model comprises three elements: the person (subject), the lesson content (object), and the tools or technology (mediating artifacts). The fundamental idea of Activity Theory (AT) is that culturally defined signs or tools influence all human activities. In other words, a person interacts with lesson content using technology or tools to accomplish a goal.

Technology and Activist Theory

In this framework, human activity is viewed as a process in which individuals interact with tools within a social context to achieve specific objectives. The theory emphasizes the dynamic and evolving nature of activities, highlighting how societal, cultural, and historical factors shape them. Activity theory is applied in various fields, including educational research. It helps to understand how learning is facilitated by tools (such as technology and language) and shaped by social interactions. Additionally, it is used to analyze work practices, design processes, and human-computer interactions.

Social Presence Theory

Social Presence Theory (SPT) was initially defined by Short, Williams, and Christie in 1976. SPT refers to the extent to which a person is perceived as a "real person" in mediated communication. It reflects the degree to which a communication medium conveys the presence of communicators. The Social Presence Theory (SPT) is also utilized in online education to enhance the learning environment by leveraging social media platforms, including Facebook, Zoom, WhatsApp, and YouTube. SPT focuses on the interaction between two individuals through verbal and visual

communication. When the medium is face-to-face, communication tends to be stronger and leads to higher satisfaction, as seen in video conferences. This medium also helps form strong interpersonal relationships through factors like gaze, gestures, voice, and facial expressions. On the other hand, communication through low mediums like email tends to result in lower participant satisfaction.

Structuration Theory

Anthony Giddens (1994) introduced the concept of structuration theory to examine the interplay between structure and agency. In this context, agency refers to the actions of individuals (human behavior), while structure encompasses the established rules and resources that shape and influence behavior (Chatterjee et.al, 2019). Giddens argues that social structure and human agency are not two separate concepts, but rather mutually constitutive as a duality; they are like two sides of a coin. In essence, Structuration Theory is a sociological theory that examines human behavior in groups and the impact of social structure.

Example: A teacher's decision to integrate technology into the classroom may be influenced by their personal beliefs and the rules established by their institution, such as the school's technology policy or the general emphasis on digital literacy. However, students' access to technology, their comfort level with it, and their resistance to new teaching methods can impact the widespread adoption of this practice. This, in turn, can affect the institution's overall approach to technology.

Technology and Structuration Theory

- The incorporation of technology in education enables interactions and learning to reach beyond the physical classroom, fostering a wider social system where educational practices can evolve more rapidly.
- The internet, online courses, and educational apps can facilitate learning across geographical locations and time zones, making education more accessible; however, they also create new challenges in terms of maintaining educational structures and standards.

Example: Online learning platforms allow students to access educational content from anywhere, at any time. This transformation alters the way the education system operates by challenging traditional classroom structures. As a result, it prompts a re-evaluation of teaching and learning methods, which can influence educational policies, assessments, and student engagement.

Constructivist Learning Theory

The central idea of constructivism is that human learning is an active process in which learners construct new knowledge and understanding based on their prior experiences and knowledge. This theory emphasizes the importance of hands-on learning, problem-solving, and critical thinking, as well as the idea that learning is a dynamic and evolving process influenced by the learner's individual experiences and perspectives.

Research Methodology

This study was designed as an exploratory investigation, employing a qualitative methodology to gain in-depth insights. It was structured as a detailed case study, allowing for a comprehensive examination of the specific context and phenomena under consideration. This approach facilitated a rich understanding of the experiences and perspectives involved. The population of this research consisted of secondary school teachers (grades 6 to 10) from a public GBSS Model Colony in Khokrapar, Karachi. All teachers belonged to the secondary sections. Most teachers had taught

there for 15 years, while some were newly appointed. The Urdu teacher was the senior instructor and managed the class with ease. The science teacher was very energetic, which made her quite popular among her students. She often used 3D models and incorporated technology into her lessons. The sample size consisted of 8 secondary school teachers for this case study. The sampling technique was purposive, as it enabled researchers to select participants who effectively met the research objectives.

Furthermore, the participants chosen were selected based on their work experience in diverse disciplines. In this study, data were collected using semi-structured interviews to gather qualitative information. The researcher conducted semi-structured interviews with the secondary teachers at the Pakistan Public GBSS Model Colony, Khokrapar, Karachi. Initially, the researcher visited the institution and obtained consent from both the institution and potential participants. The date and time were decided according to the availability of participants. Each interview lasted for about 40 minutes.

Data analysis through the Thematic process, because thematic analysis is a process used for analyzing data. It involves identifying and analyzing patterns within the data to gain insights and understanding. This method is often used in qualitative research to identify themes or patterns within the data. Inductive thematic analysis was employed to analyze the data. Participation in the interviews was voluntary. Participants were fully informed, and their right to privacy was protected through advance notice of audio recording and the absence of hidden audio recording without their permission.

To enhance the credibility of the research, the triangulation method was employed.

- *Face validity*: The interview was conducted face-to-face following the interview protocol.
- *Consent Form*: Participants were provided with a consent form and assured that their conversation would remain confidential and not be disclosed.
- *Observational Protocol*: In addition to the interview, an observational protocol was employed to analyze gestures and body language.

After collecting data to identify trends in teachers' use of low-cost technologies in public schools and finding the challenges they face while using these technologies in the classroom, Table 1 presents all four categories, each comprising eleven themes, defined by their respective codes.

Table 1: Categories, Themes, and Representatives Codes

Categories	Themes	Representative Codes
Kinesthetic Learning	3D Models, charts, Roleplay.	work in groups, motivated, engaged, and enjoyment.
Digital Learning	Mobile Phone, Laptop, Microphone	Personalized learning helps students access resources easily and receive spontaneous feedback
Digital Platform	Social Media	Should know the Pros and cons
Challenges	Outdated Curriculum, Language Barrier, Lack of resources, Digital literacy	The content and teachings methods no longer align with current knowledge and technology, which hinders effective learning and skill development

Digital Learning

Mobile Phone

According to the Pakistan Bureau of Statistics (2023) report, the total population of Pakistan is 241.49 million, with 72.99 million smartphone users, accounting for 30.3% of smartphone penetration in our society. With everything under one roof, just a tap away, mobile devices and computers have become increasingly popular during the COVID-19 pandemic (United Nations Report on COVID-19).

Personalized learning

In personalized learning, we have a class with diverse students who use different learning strategies. The teacher needs to focus on all students and plan lessons accordingly. Personalized learning can be applied in various educational settings, including traditional classrooms, online learning environments, and blended learning models.

One respondent said, "using mobile phone technologies improves personalized learning, resource access, practice, feedback, and skill development".

Another respondent said, "mobile phones are essential in our public sector, where modern-day technologies are not readily available for teaching and learning due to a lack of resources".

Feedback

Feedback is a critical component of formative assessment (Brookhart, 2008). It plays a pivotal role in the learning process of students. Positive, immediate, sincere, and kind feedback helps students learn and acquire the necessary competencies for success (Evelyn, 2022).

One participant said, "personalized learning helps students access resources easily and receive spontaneous feedback in class. Other skills are also developed when using technology in the classroom, such as gamification, virtual mentorship, and skill development".

Constructive feedback helps teachers recognize their strengths and areas that require improvement. By acknowledging their strengths and identifying areas for growth, teachers can refine their teaching methods and consistently strive for excellence (Evelyn, 2022).

Laptop

The younger generation today is used to having constant access to technology. Social media and internet sites are very popular among children, and the excessive use of cell phones, laptops, computers, and gaming devices can lead to hypertension in children (Carsten, 2021; Bond & Bandenlier, 2019). With technology, learners can acquire information more quickly, have time to express their thoughts, engage in both online and offline discussions, and access educational resources at their own pace (Mahini, 2012).

One respondent said, "the integration of laptops and USB technologies in educational settings has significantly enhanced the process of personalized learning. It has provided students with improved access to educational resources, facilitated more opportunities for practice and feedback, and contributed to the development of essential skills".

Technology enables students to learn quickly and easily, but they also need support from parents, friends, coaches, and others. Student performance can be assessed through various methods, including class assessments, exams, grades, punctuality, attendance, and other quantitative and qualitative data sources (Duggan, 2020).

Microphone

The number of students enrolled in public schools is huge. Sometimes, 40 to 50 students are seated in the same class. A teacher cannot teach very loudly. Even a simple microphone and speaker can enhance students' learning, allowing them to focus and engage in the classroom, and also leading to improvements seen in their behavior.

One participant said, "it depends, sometimes we use the model to teach the students about the topic, students work in groups, and with the collaboration of students, we deliver the activity smoothly, for this, I can use a microphone. There are several advantages to using a microphone in class, including maintaining calmness and assisting learners who experience hearing difficulties. I feel very comfortable when I use Mike because I can speak gently and slowly, not pressured on my throat".

Findings and Discussion

After collecting data to identify trends in teachers' use of low-cost technologies in public schools and finding the challenges they face while using these technologies in the classroom, Table 1 presents all four categories, each comprising eleven themes, defined by their respective codes. Four categories are Kinesthetic learning, Digital learning, Digital platforms, and Challenges. The primary finding highlighted that the actual state of our public schools' teachers is that they are creatively incorporating a variety of effective, low-cost technologies into their classrooms. The integration of technologies in educational settings has significantly enhanced the process of personalized learning. It has provided students with improved access to educational resources, facilitated more opportunities for practice and feedback, and contributed to the development of essential skills. Some participants focus on 3D models. 3D models can be utilized to create personalized learning experiences for students. Educators can develop 3D models and simulations tailored to each student's unique needs, allowing them to progress at their own pace and focus on areas where they require additional support (Wang, 2022). This approach aligns with constructivist theory, as it allows students to interact, explore, and manipulate learning materials in ways that suit their individual learning styles and levels of understanding. Using mobile phone technologies enhances personalized learning, access to resources, practice, feedback, and skill development. This fosters a stronger social presence, making individuals feel more connected, supported, and engaged even outside the classroom. By leveraging these resources, they enhance the learning experience and engage their students in innovative ways, demonstrating their commitment to providing quality education despite limited funding. Technology enables students to learn quickly and easily, but they also need support from parents, friends, coaches, and others. Student performance can be assessed through various methods, including class assessments, exams, grades, punctuality, attendance, and other quantitative and qualitative data sources (Duggan, 2020). Secondary findings suggest that teachers utilize mobile phones to facilitate correct pronunciations and gather ideas for charts, role-plays, science projects, and other types of assignments. The other main findings focus on the challenges (outdated curriculum, language barriers, lack of resources, and digital literacy) that teachers face when integrating technology into the classroom. Specifically, teachers have a significant responsibility to educate students about the importance of being safe, responsible, and respectful when using online resources.

Conclusion

The findings suggest that public school teachers are increasingly using low-cost technologies on their own initiative. They seek permission from school management before incorporating these

tools into their classrooms. This includes open-source software such as Google Chrome, Python, and Firefox, as well as mobile apps for gaming, productivity, and health tracking. Additionally, it encompasses recycled hardware, including charts and models, to enhance instructional delivery. Many of our teachers lacked proper digital training, which resulted in an inefficient use of technology in the classroom.

The findings highlight the increasing availability of educational tools and the feasible integration of technology, even in environments with limited resources.. For policymakers, this highlights the importance of investing in teacher training, infrastructure, curriculum development, and financial support to leverage these technologies fully. The research provides valuable and current information on emerging low-cost technologies. However, its scope is constrained by its reliance on self-reported data from educators, which might not comprehensively reflect the actual extent of technology integration in educational settings. Additionally, the focus of this research is on a specific area, and it is a case study; the findings may be limited. Future research could explore the primary level because this study focuses on secondary-level teachers, the technologies they use, and the challenges they face while teaching in a class. Researchers also investigate the long-term effects of low-cost technologies on both learners and educators.

Recommendations

The integration of technologies in educational settings has significantly enhanced the process of personalized learning. These technological tools have been successfully integrated into classroom instruction. The focus of this research is on a specific area, employing a case study approach that may limit the generalizability of the findings. Recommendations are made based on conclusions.

- The school management offers essential resources to enhance the learning environment, including a reliable Wi-Fi connection and multimedia tools. These resources are designed to support students and educators in their teaching and learning activities.
- Organize workshops and training programs to help teachers effectively integrate low-cost technologies into their teaching methods. Create online resources and communities for educators to share best practices and innovative strategies.
- Policymakers and school administrators should allocate funds to support affordable technology initiatives, as well as work on curriculum development and provide digital platforms.
- Schools should also provide incentives for teachers who creatively utilize cost-effective tools to enhance learning. Encourage the use of open-source software, free educational apps, and online platforms that offer high-quality learning materials at minimal or no cost.
- Educational institutions should integrate affordable technology solutions into curricula and lesson plans to ensure sustainable implementation. Additionally, they should develop subject-specific guidelines on how teachers can effectively use these technologies. Create platforms for teachers to share experiences and success stories about low-cost technology use.

References

- Abbasi, A. M., Lashari, A. A., Kumar, H., Khan, S., & Rathore, K. (2019). Impact of Facebook on the trends of university students. *Journal of Social Sciences and Media Studies*, 3(2), 29-37.
- Ahmed, I., (2014)._Critical Analysis of the Problems of Education in Pakistan: Possible Solutions. *International Journal and Evaluation and Research in Education (IJER)*, 3(2), 79-84.
- Amara, S., Macedo, J., Bendella, F., & Santos, A. (2016). Group formation in mobile computer supported collaborative learning contexts: a systematic literature review. *Journal of Educational Technology & Society*, 19(2), 258-273.

- Baker, RS. (2019). *2 Artificial Intelligence in Education: Bringing it all Together*. Penn Center for Learning for Analytics, <https://learninganalytics.upenn.edu>
- Bond M., & Bedenlier S. (2019). Facilitating student engagement through educational technology: Towards a conceptual framework. *Journal of Interactive Media in Education*. 11, 1-14,
- Brookhart, S.M. (2008), Effective Feedback, *Association for Supervision Curriculum and Development ASCD*, <https://perino.pbworks.com>
- Cappola, R.A. (2020). Use of Technology with Low-Income Students: How Schools Can Help Students Succeed. *Bethel University*, <https://spark.bethel.edu/etd/105>
- Carsten, K.J. (2021). Effects of Technology on Student Learning. *The Turkish Online Journal of Educational Technology*, 20(1), 105-106
- Chatterjee, I., Kunwar, J., & den Hond, F. (2019). Anthony Giddens and structuration theory. In S. Clegg, & M. Pina e Cunha (Eds.), *Management, Organizations and Contemporary Social Theory*. Routledge, 60-79.
- Coflan, C. M., & Kaye, T. (2020). Using Education Technology to Support Students with Special Educational Needs and Disabilities in Low- and Middle-Income Countries. (*EdTech Hub Helpdesk Response No. 4*). *EdTech Hub*. <https://doi.org/10.53832/edtechhub.0021>
- Cotton, SR. et.al., (2011). Using Affordable Technology to Decrease Digital Inequality, *Information. Communication and Society*, 14(4), pp. 424-444, DOI: 10.1080/1369118X.2011.559266
- Cowan, P., & Butler, R. (2013). Using activity theory to problematize the role of the teacher during mobile learning. *SAGE Open*, 3(4), 2158244013516155
- DePasse, J. W., Caldwell, A., Santorino, D., Bailey, E., Gudapakkam, S., Bangsberg, D., & Olson, K. R. (2016). Bringing value-based design into global health. *BMJ Innovations*, 2(1), 4-7. <https://doi.org/10.1136/bmjinnov-2015-000069>
- Du, X. (2022). The path of artificial intelligence technology to reduce cost and increase efficiency of e-commerce supply chain. *Proceedings of the 2022 International Conference on E-Commerce and Internet Technology (ECIT 2022)*. ACM Digital Library. <http://dl.acm.org>
- Duggan (2020), AI in Education: Change at the Speed of Lightning, *UNESCO Institute for Information Technology in Education (IITE)*, www.iite.unesco.org
- Ellahi, A. (2018). Social networking sites as formal learning environments in business education. *Journal of Educational Technology & Society*, 21(4), 64-75.
- Evelyn, R. (2022). The Role of Feedback in the Learning Process of Students, *Journal of Educational Studies*, 4(1), pp. 5-30.
- Firmin, M.W. (2013). History and Implementation of Classroom Technology. *Procedia - Social and Behavioral Sciences*, 93, 1603-1617, <https://doi.org/10.1016/j.sbspro.2013.10.089>.
- Fayyaz, S., Lashari, A. A., Nandwani, S., & Chang, M. A. (2023). Assessing environmental awareness and conservation behavior in schools for sustainable development. *Pakistan Journal of Humanities and Social Sciences*, 11(4), 4070-4081.
- Goodman, C.S. (2014). HTA 101- An Introduction to Health Technology Assessment. *National Library of Medicine*.
- Govindan, K., Shaw, M., & Majumdar, A. (2021). Social sustainability tensions in multi-tier supply chains: A systematic literature review towards conceptual framework development. *Journal of Cleaner Production*, 279, 123838. <https://doi.org/10.1016/j.jclepro.2020.123838>
- Harris, J.L. (2016). One-to-One Technology and its Effect on Student Academic Achievement and Motivation. *Contemporary Educational Technology*, 7(4), 368-381.
- Herschbach, Dennis, R. (1995). Technology as Knowledge: Implications for Instruction. *Journal of Technology Education*, 7(1). doi:10.1108/10748120110424816
- Imran, Q., Kazimi, A. B., & Lashari, A. A. (2022). Examining the impact of extrinsic and intrinsic barriers to adopting information communication technology in classroom teaching in intermediate (K 12) colleges of Karachi, Pakistan. *Journal of Positive School Psychology*, 2458-2478.

- Johnson, A. M., Jacovina, M. E., Russell, D. E., & Soto, C. M. (2016). Challenges and solutions when using technologies in the classroom. *Adaptive educational technologies for literacy instruction*, 13-29
- Kajamaa, A. (2020). Teacher Interventions in Students' Collaborative Work in a Technology-rich Educational Maker Space, 2(51), 371-386.
- Kamp, A. (2019). Science and Technology Education for 21st Century Europe. *Ceaser*, Doi: 10.5281/Zenodo.3582544.
- Kikot, T., (2013). Simulation games as tools for integrative dynamic learning: The case of the management course at the University of Algarve, *Procedia Technology*, 9, 11 – 21, doi:10.1016/j.protcy.2013.12.002
- Lashari, A. A., Umrani, S., & Buriro, G. A. (2021). Learners' self-regulation and autonomy in learning English language. *Pakistan Languages and Humanities Review*, 5(2), 115-130.
- Lashari, A. A., & Umrani, S. (2023). Reimagining self-directed learning language in the age of Artificial Intelligence: A systematic review. *Grassroots (1726-0396)*, 57(1).
- Lindell T.L. (2022). Teacher's Challenges and School Digitalization. *Diva Portals*,
- Mahini, F. (2012). The Importance of Teacher's Role in Technology-Based Education. *Procedia social and behavioral sciences*, 46,1614-1618
- Pal, G.C. (2020). School Readiness Among the Underprivileged. *Sage Journals*, 2(17). doi:10.1177/0973184920931772
- Pinto, M. (2020). Digital Technologies in Support Students Learning in Higher Education: Literature Review. *ERIC Education Resources Information Center*; <http://greav.ub.edu/der>
- Prensky M. (2001). Digital Natives Digital Immigrants. *On the Horizon*, 9(5), 1-6.
- Refer, A. (2017). Bridging the Gap: Underserved Populations and Technology. *Digital Commom Macalester*,
- Salman, H., Rahat, A., & Lashari, S. N. A. A. (2023). Implication of sustainable development goals for quality education in institutions of higher education in Pakistan. *Journal of Positive School Psychology* <http://journalppw.com>, 7(4), 1866-1873.
- Samah H. Almaki, Mnyero A. Gunda, Khairuddin Idris, Abdul Talib M. Hashim & Siti Rahaimah Ali. (2023). A systematic review of the use of simulation games in K-12 education, *Interactive Learning Environments*, DOI: [10.1080/10494820.2023.2205894](https://doi.org/10.1080/10494820.2023.2205894)
- Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2017). Computer-based technology and student engagement: A critical review of the literature. *International Journal of Educational Technology in Higher Education*, 14(1), 25. <https://doi.org/10.1186/s41239-017-0063-0>
- Sissoko, P. (2022). Effects of low-cost agricultural technology package on income, cereal surplus production, household expenditure, and food security in the drylands of Mali. *AIMS Agriculture and Food*, 1(7),
- Subramaniam, S. (2017). Leveraging Technology for Educational Inclusion. *Universal Journal of Educational Research*, 5(1), 94-98, DOI: 10.13189/ujer.. 2017.050111.
- Tabassum, R. (2020). Education Technology in the Covid-19 response in Pakistan. *Ed Tech Hub*, <https://edtechhub.org>
- Towse, A. (2018). Affordability of New Technology: The Next Frontier. *Value in Health*, 21(3), 249-251, <https://doi.org/10.1016/j.jval.2018.01.011>
- Wenglinsky, H. (1998). Models of the relationships between education spending and the social distribution of achievement. *ETS Research Report Series*, 1998(1), i-29. <https://doi.org/10.1002/j.2333-8504.1998.tb01792.x>
- Zhang, J. (2015). Learning on The Fingertips: The Opportunities and Challenges of Educational Apps. *Journal of Education and Practice*, 6(20), <https://www.files.eric.ed.gov>
- Zubairi, A., Kreimeia, A., Jefferies, K., Nicolai, S. (2021). EdTech to Reach the Most Marginalised: A Call to Action. *Position paper*, EdTech Hub. <https://doi.org/10.53832/edtechhub.0045>.