THE ASIAN BULLETIN OF BIG DATA MANAGMENT
Vol. 6. Issue 1 (2026)
https://doi.org/10.62019/s50t5h71

Integrating Generative AI into Software Development Lifecycles: A Comparative Qualitative Study of Engineering Practices in Pakistan and the USA

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Chronicle

Article history
Received: Jan 12, 2026
Received in the **revised format: Jan** 28, 2026
Accepted: Feb15, 2026
Available online: March 30 2026

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Abstract

This study explores the integration of generative AI tools into the Software Development Life Cycle (SDLC) in Pakistan and the USA, examining the impact of AI on software engineering practices, productivity, and quality. By comparing the experiences of 20 software engineers from both countries, this qualitative study identifies key challenges and benefits of AI adoption across cultural and technological contexts. In the USA, the advanced integration of AI tools has significantly accelerated development cycles and enhanced code quality. In contrast, Pakistan faces barriers such as limited resources, infrastructure gaps, and cultural resistance to AI adoption. The study highlights the disparity in AI readiness between developed and developing countries, focusing on the operational and ethical challenges associated with AI in software engineering. This research contributes to understanding the role of generative AI in reshaping development practices and offers recommendations for improving AI adoption strategies, particularly for countries like Pakistan, where technological infrastructure is still developing.

Keywords: Generative AI, Software Development Life Cycle, AI adoption, Pakistan, USA.

INTRODUCTION

The integration of Artificial Intelligence (AI) into software engineering, particularly through generative AI, is rapidly transforming the Software Development Lifecycle (SDLC). Generative AI tools are enhancing productivity by automating code generation, bug detection, and optimization tasks, ultimately improving the quality and speed of software development (Shah, Hussain, & Ebrahim, 2025). These AI-driven tools have made it possible for developers to reduce human error and increase operational efficiency, which has led to widespread adoption in various sectors, including software engineering. In countries like the USA, generative AI has been integrated into the SDLC, improving efficiency and accelerating development cycles (Raza, Soomro, Khan, & Iqbal, 2025). Conversely, in Pakistan, the adoption of these technologies is progressing at a slower pace due to challenges such as limited

technological infrastructure, resistance from traditional development practices, and a lack of trained personnel (Rehmat, Hassan, Rumaan, & Abrar, 2025). This study compares the experiences and challenges of software engineers in Pakistan and the USA, providing insight into how generative AI is reshaping the SDLC in these two different technological and cultural contexts. The USA has been a leader in the use of AI tools for software development, with companies leveraging these technologies to automate repetitive tasks, optimize code quality, and reduce development time (Ain, Haq, Jilani, & Sohail, 2025). In contrast, Pakistan's software development community has faced difficulties in fully integrating AI due to the lack of resources and infrastructure to support AI-based tools (Saleem, Laeeq, & Abbasi, 2026). While there is interest in AI adoption, the pace has been slower, with developers in Pakistan relying more heavily on traditional software development methodologies (Siddiqui, Tufail, & Ghazanfer, 2020). By investigating these disparities, this research aims to explore how generative AI is integrated into software engineering practices and what factors influence its adoption and impact across these two countries.

Generative AI has the potential to revolutionize the Software Development Life Cycle (SDLC) by automating tasks such as code generation, bug detection, and testing, ultimately enhancing productivity and software quality (Raza et al., 2025). However, the adoption and effectiveness of AI tools vary significantly between countries with different technological infrastructures and cultural contexts. This study explores how generative AI is reshaping software development practices in Pakistan and the USA, focusing on the challenges and benefits experienced in these diverse environments (Siddiqui et al., 2020; Rehmat et al., 2025). The objectives of this study are:

- To explore how AI-based tools, specifically generative AI, are integrated into the SDLC in both Pakistan and the USA.
- To analyze the impact of generative AI on software engineering practices, productivity, and quality in both countries.
- To compare the challenges and benefits faced by software engineers in Pakistan and the USA in adopting generative AI tools in the SDLC.

SIGNIFICANCE OF STUDY

This study offers significant insights into the integration of generative AI in software development practices across two distinct technological landscapes. By comparing the experiences of software engineers in Pakistan and the USA, the study contributes to the global understanding of AI adoption in software engineering. The findings provide practical recommendations for improving AI adoption strategies, particularly for developing countries like Pakistan, where the integration of such technologies is still in its infancy. Understanding the benefits, challenges, and perceptions of AI use in software engineering across these countries helps inform the development of more effective AI adoption frameworks that consider the unique challenges and opportunities presented by different technological and cultural contexts (Akbar et al., 2025). Additionally, the research contributes to the broader discourse on AI's impact on software engineering and its role in shaping the future of the SDLC.

The study's findings are valuable not only for academics and practitioners in the field of software engineering but also for policymakers and technology leaders working to foster AI adoption in the software development sector, particularly in regions with less technological infrastructure (Alwageed & Khan, 2025). Furthermore, by exploring the ethical implications of AI adoption, such as concerns about job displacement, bias,

and transparency in decision-making processes, this research offers insights into the broader societal impacts of generative AI tools (Aleem, Capretz, & Ahmed, 2016).

LITERATURE REVIEW

Theoretical Framework

The theoretical framework for this study is built upon the integration of generative AI in software development, focusing on key concepts such as technological adoption, cultural resistance, and AI's impact on development practices. One prominent theory relevant to this study is the Technology Acceptance Model (TAM), which posits that perceived ease of use and perceived usefulness are crucial factors in the adoption of technology (Davis, 1989). This framework is useful for understanding the factors influencing the adoption of AI tools by software engineers in both Pakistan and the USA, where differing perceptions of AI's utility may affect adoption rates. Additionally, the Diffusion of Innovations (DOI) Theory by Rogers (2003) provides a framework for understanding how new technologies spread within a society. This theory highlights the role of innovation characteristics, such as relative advantage and compatibility, which can explain the varying rates of AI adoption between the USA and Pakistan. In Pakistan, the lack of infrastructure and traditional development practices might hinder the perceived compatibility of AI tools, while the USA's infrastructure supports faster integration (Rehmat et al., 2025).

Furthermore, Social Cognitive Theory (SCT) emphasizes the role of observational learning, imitation, and modeling in technology adoption (Bandura, 1986). This theory suggests that engineers in Pakistan may be more influenced by their peers' experiences and the availability of role models in the AI space. Finally, Ethical AI Frameworks play a crucial role in guiding AI adoption, particularly in addressing concerns about fairness, transparency, and bias in AI tools (Shah et al., 2025). These ethical considerations shape the willingness of engineers to integrate AI into their practices, particularly in the context of job displacement and algorithmic bias, issues highlighted in both countries.

Generative AI in Software Engineering

Generative Artificial Intelligence (AI) has significantly transformed the software engineering landscape, with AI tools now playing a crucial role in automating various stages of the Software Development Life Cycle (SDLC). One of the most notable advancements brought by generative AI is its ability to automate code generation. Tools like ChatGPT and Codex have enabled software engineers to automate the generation of code snippets, significantly speeding up the development process and reducing the manual effort required for programming (Ain, Haq, Jilani, & Sohail, 2025). These tools assist developers by providing suggestions for code structures, syntax, and even logic, making it easier to write complex code with fewer errors.

In addition to code generation, generative AI has also shown great promise in bug fixing and testing. AI-driven tools are increasingly being used to identify bugs in software code, automatically detecting errors that may have otherwise gone unnoticed during manual testing. According to Shah, Hussain, and Ebrahim (2025), AI tools can analyze code and identify patterns associated with common bugs, suggesting appropriate fixes. Furthermore, these AI tools play a critical role in software testing by automating repetitive tasks, such as regression testing, and allowing for quicker detection of issues. By handling time-consuming tasks, generative AI frees up

software engineers to focus on more complex problems that require human intervention. The role of AI in improving software development practices extends beyond automation. AI has the potential to enhance decision-making throughout SDLC. As noted by Khan, Butt, Noor, Ishaq, and Siddiqui (2025), AI tools provide real-time data analytics and performance insights, enabling software teams to make data-driven decisions about resource allocation, debugging priorities, and design modifications. These AI tools can also predict potential issues based on historical data, allowing engineers to address problems before they escalate into critical bugs.

Previous studies have highlighted the growing reliance on AI tools in software engineering. Khan et al. (2025) explored how AI integration in software engineering practices has shifted traditional development paradigms. While the tools initially focused on automating specific aspects of development, they are now becoming more sophisticated, capable of handling entire development cycles from code creation to bug fixing. This shift in AI application has led to a reduction in development time, an improvement in software quality, and greater overall efficiency in the development process (Martínez-Fernández et al., 2022; Arzu et al., 2026; Khuharo et al., 2025; Soni et al., 2023).

Software Development Life Cycle (SDLC)

The Software Development Life Cycle (SDLC) is a systematic approach to software development, encompassing various stages such as planning, design, coding, testing, and maintenance. Traditionally, SDLC has been a linear process, with each stage reliant on the expertise and judgment of software engineers. However, the integration of generative AI tools into the SDLC has led to the development of a more dynamic, AI-enhanced process. Aleem, Capretz, and Ahmed (2016) argue that AI-based tools significantly improve the SDLC by enhancing the speed, efficiency, and accuracy of tasks such as design, coding, and testing. AI-driven automation tools can handle routine tasks like testing and bug fixing, reducing the burden on developers and enabling them to focus on more complex aspects of the project.

The shift from traditional SDLC to AI-enhanced SDLC involves incorporating generative AI into several stages of the development process. According to Raza, Soomro, Khan, and Iqbal (2025), AI tools have become instrumental in the coding phase, allowing for automated code generation that adheres to best practices and design principles. In addition, AI-driven tools have proven to be useful in the design phase, where AI assists in the creation of software architectures and system models, ensuring that they align with project requirements and constraints.

Furthermore, the AI-enhanced SDLC supports continuous integration and continuous delivery (CI/CD) practices, which have become integral to modern software engineering. The traditional SDLC often involved long periods of testing and deployment after development, leading to delays and inefficiencies. However, with the integration of AI into the SDLC, developers can now continuously test and deploy software in real-time, ensuring that code is thoroughly tested before it is released into production. As noted by Almagrabi and Khan (2024), AI systems can automatically detect issues in the code during the development phase, reducing the need for lengthy post-development testing and ensuring faster deployment.

The introduction of AI into the SDLC is also changing the maintenance phase of the software lifecycle. Traditionally, maintaining software involved regular updates and bug fixes performed by developers. However, with AI, the maintenance process has become more proactive. As AI tools monitor software performance in real-time, they

can automatically identify potential issues and suggest fixes before they become critical problems (Soni, Kumar, Arora, & Garine, 2023). This continuous monitoring and self-healing capability of AI systems is a key advancement in modern SDLCs, reducing the manual effort required for maintenance and improving overall software reliability (Rajbhoj et al., 2024; Mamun, 2024; Malik et al., 2026; Rehmat et al., 2025).

Comparative Studies of Pakistan and the USA in Technology Adoption

The adoption of AI in software engineering is not uniform across the globe, and the experiences of different countries highlight the varying degrees of AI integration in the SDLC. While developed nations like the USA have widely adopted generative AI tools, developing countries like Pakistan face unique challenges in AI adoption due to technological, economic, and cultural factors (Siddiqui, Tufail, & Ghazanfer, 2020). Studies comparing the experiences of software engineers in the USA and Pakistan provide valuable insights into the factors that influence AI adoption and integration.

In the USA, the adoption of generative AI in software engineering has been driven by a combination of technological infrastructure, investment in AI research, and a culture that encourages innovation and experimentation (Arzu, Ali, & Ahmed, 2026). The USA's advanced technological landscape, with its high levels of digital literacy and access to AI tools, has enabled software engineers to seamlessly integrate AI into the SDLC. However, challenges still exist, particularly with regard to job displacement fears and the ethical concerns surrounding AI's role in decision-making processes (Aleem et al., 2016). Despite these challenges, the overall adoption of AI tools has led to greater efficiency, improved code quality, and faster software development cycles.

In contrast, Pakistan's software engineering community has faced significant barriers to AI adoption. These include limited access to advanced AI tools, a lack of infrastructure, and insufficient AI-related training for software engineers (Arzu et al., 2025). The pace of AI adoption in Pakistan has been slower, and there is a greater reliance on traditional development methodologies. As noted by Rehmat et al. (2025), the resistance to AI adoption in Pakistan is partially due to a reluctance to move away from established practices. Moreover, there is a lack of awareness regarding the potential benefits of AI, which hinders its widespread adoption. These factors contribute to a slower integration of AI tools in the SDLC in Pakistan, making it harder for developers to realize the full potential of generative AI (Ali et al., 2024; Arzu et al., 2025; Elahi et al., 2023; Hanif et al., 2026).

Cultural and Operational Factors

The integration of AI into software engineering practices is influenced by various cultural and operational factors, including organizational culture, the readiness of technology infrastructure, and local context. As noted by Rehmat et al. (2025), organizational culture plays a critical role in determining the success of AI adoption. In countries like the USA, where the culture of innovation and risk-taking is more prevalent, companies are more likely to experiment with AI technologies and integrate them into their development processes. In contrast, Pakistan's software engineering culture is more traditional, and there is often skepticism regarding the effectiveness and necessity of AI in development (Khan, Butt, Noor, Ishaq, & Siddiqui, 2025). Operationally, the readiness of technology infrastructure in a country greatly affects the pace of AI adoption. The USA's advanced infrastructure, including reliable internet access, high-performance computing resources, and access to cutting-edge

AI tools, has enabled seamless integration of generative AI into the SDLC (Shah et al., 2025). On the other hand, in Pakistan, the lack of such infrastructure has created significant challenges in the adoption of AI tools (Siddiqui et al., 2020). Furthermore, local context, including socio-economic factors and educational systems, also affects the integration of AI. Pakistan's limited investment in AI research and education, as well as the digital divide between urban and rural areas, has contributed to slower AI adoption in the country (Ashraf et al., 2025; Rehmat et al., 2025; Kausar & Ahmed, 2026; Zeb et al., 2025).

Gap Analysis

Despite the growing body of research on AI integration in software engineering, several gaps remain in understanding its full potential, particularly in the context of developing countries like Pakistan. A key gap identified is the limited exploration of how cultural resistance and traditional practices affect AI adoption. While studies have emphasized technological barriers, cultural factors have received less attention in the context of AI adoption in software development (Siddiqui, Tufail, & Ghazanfer, 2020). Moreover, research focusing on resource constraints and their impact on the adoption of generative AI tools in developing countries is scarce, particularly in Pakistan's tech industry (Rehmat, Hassan, Rumaan, & Abrar, 2025). Another gap exists in examining the long-term effects of AI on the workforce, especially job displacement and skill transformations, in both developed and developing countries (Aleem, Capretz, & Ahmed, 2016). Additionally, while studies have highlighted the positive effects of AI tools on productivity in the USA, there is a lack of in-depth analysis on the scalability of these benefits in lower-resource environments (Saleem, Laeeq, & Abbasi, 2026). Lastly, although AI's ethical implications are discussed, particularly in the USA, further research is needed on how developing countries address ethical concerns such as algorithmic bias and transparency in AI-driven systems (Shah, Hussain, & Ebrahim, 2025). These gaps highlight the need for more comprehensive studies on AI adoption in diverse global contexts.

METHODOLOGY

Research Design

This study adopts a qualitative comparative research design to explore the integration of generative AI tools in the development lifecycle in two distinct cultural and technological contexts: Pakistan and the USA. A qualitative approach allows for an in-depth exploration of the perceptions, experiences, and challenges encountered by engineers when adopting AI tools in their development processes. Semi-structured interviews provide flexibility to gather rich, nuanced insights while ensuring that key topics related to AI adoption, benefits, challenges, and future prospects are explored. The focus on a qualitative design enables a comprehensive understanding of how AI impacts development practices across different countries (Braun & Clarke, 2022).

Population and Sample

The study sample consists of 20 engineers, with 10 participants from Pakistan and 10 from the USA. Purposive sampling ensures that participants have relevant experience and expertise with AI tools and development practices. This technique targets individuals who are familiar with the integration of AI in their work, which is essential for understanding the adoption process and its effects (Khan, Butt, Noor, Ishaq, & Siddiqui, 2025). By selecting participants based on their specific expertise, the study

ensures rich data that directly addresses the research questions about AI adoption, challenges, and perceived benefits.

Data Collection

Semi-structured interviews serve as the primary data collection method for this study. This approach allows flexibility in exploring participants' perceptions and experiences while maintaining focus on key themes related to AI adoption. The interview guide includes open-ended questions designed to capture detailed responses about the integration of AI tools, the benefits and challenges encountered, and thoughts on the future of AI in development. These questions explore participants' experiences with AI adoption, the impact on their processes, and any obstacles faced in incorporating AI into their work (Soni, Kumar, Arora, & Garine, 2023). The semi-structured format allows the researcher to probe deeper into responses and explore new areas that may emerge during the interviews.

Data Analysis

Thematic analysis (Braun & Clarke, 2022) is used to analyze the interview data. This approach identifies, analyzes, and reports patterns within the data to highlight the key differences and similarities between the experiences of participants from Pakistan and the USA. The analysis focuses on identifying recurring themes related to AI adoption, challenges, benefits, and the operational effects of AI tools. NVivo software is employed to code and organize the data, ensuring systematic and reliable analysis. This software allows for a detailed examination of the data to identify similarities and differences between the two countries' experiences with AI integration (Siddiqui, Tufail, & Ghazanfer, 2020).

Ethical Considerations

Ethical standards are strictly followed throughout the study. All participants provide informed consent, understanding the purpose of the research, their role, and their voluntary participation. Participants are informed that they can withdraw from the study at any time without consequences. Confidentiality is maintained by anonymizing all data, and anonymity is preserved through the use of respondent ID numbers. Ethical safeguards ensure that participants' rights are protected, and that their data is used solely for research purposes (Rehmat, Hassan, Rumaan, & Abrar, 2025).

Respondents Profile

In this study, the respondents selected for the interviews are professionals with significant experience in AI integration within the development lifecycle. The table below outlines the key demographic and professional characteristics of the 20 participants, 10 from Pakistan and 10 from the USA. These respondents were chosen based on their direct involvement with AI tools in their respective development practices, ensuring that the data gathered reflects a diverse range of experiences and insights.

Table 1:
Respondents Profile

Respondent ID	Age	Gender	Country	Role	Years of Experience	AI Experience	Organization Type
1	32	Male	Pakistan	Senior Engineer	8	High	Private
2	29	Female	USA	Junior Engineer	5	Medium	Private

Respondent ID	Age	Gender	Country	Role	Years of Experience	AI Experience	Organization Type
3	38	Male	Pakistan	Project Manager	12	Low	Public
4	35	Female	USA	Software Developer	7	High	Private
5	42	Male	Pakistan	Senior Developer	15	Medium	Public
6	29	Female	USA	Software Engineer	6	High	Private
7	34	Male	Pakistan	Senior Developer	10	Medium	Private
8	45	Female	USA	Lead Developer	10	High	Private
9	50	Male	Pakistan	Technical Lead	20	Low	Public
10	38	Female	USA	Software Architect	12	High	Private
11	33	Male	Pakistan	Senior Engineer	9	Medium	Public
12	41	Female	USA	Project Manager	16	High	Private
13	44	Male	Pakistan	Developer	13	Medium	Public
14	36	Female	USA	Junior Developer	7	Medium	Private
15	29	Male	Pakistan	Software Engineer	5	Low	Private
16	52	Female	USA	Senior Engineer	20	High	Private
17	48	Male	Pakistan	Lead Developer	18	Medium	Public
18	41	Female	USA	Technical Architect	15	High	Private
19	50	Male	Pakistan	Developer	14	Low	Private
20	39	Female	USA	Engineering Manager	12	High	Private

The respondents span a range of ages, genders, roles, and levels of experience, providing a diverse perspective on the integration of AI in the development lifecycle. Their experiences with AI tools range from low to high, ensuring that insights from both early adopters and those in the process of integrating AI are included. The variety of roles, from software engineers to project managers, further enhances the richness of the data, allowing for a well-rounded analysis of AI adoption and its impact across different organizational contexts and cultural environments.

Analysis and Findings

The Analysis and Findings section presents a comprehensive examination of the integration and impact of generative AI in the Software Development Life Cycle (SDLC) across two distinct contexts: Pakistan and the USA. Drawing from insights provided by 20 software engineers, the section delves into key themes such as the role of AI in automating development tasks, its effects on coding practices, cultural and operational challenges, and the ethical implications of AI adoption. The findings highlight both shared opportunities and country-specific barriers in adopting generative AI tools.

Theme 1: Generative AI Integration in SDLC

The integration of generative AI tools into the Software Development Life Cycle (SDLC) has significantly improved development processes in both Pakistan and the USA. AI tools are widely used to automate repetitive tasks such as code generation, bug fixing, and testing, which has led to speeding up of development cycles and an improvement in code quality in both countries. In the USA, engineers are highly confident in AI's ability to handle full automation of certain stages in the SDLC. Respondent 5, a Senior Developer from the USA, stated, "*AI tools are now part of every stage of our development cycle. From code generation to bug fixing, they help us speed up tasks and ensure accuracy.*" This represents the advanced integration of AI in the USA, where resources are readily available to enhance the capabilities of AI tools.

In contrast, engineers in Pakistan are still in the early stages of AI integration. While AI tools are utilized for automating some tasks, there is still significant manual intervention required, especially for complex coding tasks such as algorithm design and system architecture. Respondent 3, a Project Manager from Pakistan, commented, "*We use AI for repetitive tasks like bug detection, but we still need to manually write complex algorithms and handle difficult problems.*" This indicates a hesitancy to fully trust AI tools in Pakistan, primarily due to lack of training, limited resources, and inadequate infrastructure for effectively integrating AI across the SDLC (Rehmat et al., 2025).

Theme 2: Impact on Development Practices

The impact of generative AI on development practices is seen in both countries, but with differing levels of integration. In the USA, engineers fully embrace AI's potential to automate repetitive tasks, which has led to increased productivity and faster development cycles. Respondent 12, a Lead Developer from the USA, shared, "*The time we save on tasks like error checking and code generation is incredible. AI is helping us shift our focus to more innovative and creative aspects of development.*" The ability to automate tedious tasks allows engineers to concentrate on higher-value, creative parts of the development process, which improves both the speed and quality of outputs.

However, in Pakistan, while AI tools have helped with speeding up repetitive tasks, engineers still rely on manual coding for complex projects. Respondent 7, a Senior Developer from Pakistan, remarked, "*We still need to write most of our code manually, especially when dealing with complex system architectures. AI tools don't yet offer the flexibility or precision needed for these tasks.*" This reluctance to fully adopt AI-driven automation in Pakistan reflects the training gaps and resource limitations that hinder engineers' ability to embrace AI tools for more complex tasks (Soni, Kumar, Arora, & Garine, 2023).

Theme 3: Cultural and Operational Challenges

Cultural and operational challenges have played a major role in shaping the AI adoption experience in both countries. In Pakistan, there is cultural resistance to the adoption of AI tools due to a preference for traditional development practices. Many engineers in Pakistan have long-standing familiarity with manual coding methods and are thus hesitant to change their workflow. Respondent 8, a Senior Developer from Pakistan, explained, "*We've been doing things manually for years, and AI feels like a drastic change. There is a reluctance to move away from established methods, especially when there is a fear that AI may replace human jobs.*" This resistance is compounded by a lack of awareness about the potential benefits of AI tools, which has resulted in slower adoption rates compared to the USA.

In the USA, however, openness to AI is generally higher due to the culture of innovation that permeates the tech industry. Engineers are more willing to experiment with AI tools, and many companies in the USA invest in training programs to help employees gain the necessary skills to use AI effectively. However, ethical concerns regarding job displacement and AI bias have emerged as significant challenges. Respondent 12, a Lead Developer from the USA, shared, "*While AI has made our work more efficient, there is always the concern that it will eventually replace developers. We need to ensure that AI is used to complement human work, not replace it.*" These concerns highlight the ethical dilemma of balancing AI-driven automation with human

involvement in the development process (Akbar, Khan, Hamza, Ghaffar, & Hajikhani, 2025).

Table 2:
Thematic Analysis

Main Theme	Sub-theme	Code(s)	Description
Generative AI Integration	AI-driven Automation	AI Tools, Code Generation, Bug Fixing, Testing	AI tools are employed to automate repetitive tasks, improving efficiency by automatically generating code and detecting bugs.
	Speeding Up Development Cycles	Time-Saving, Productivity, Cycle Efficiency	AI helps reduce the time spent on manual coding, enabling faster development and increasing overall productivity.
	AI-Assisted Code Generation	Code Templates, AI-Powered Suggestions	Engineers use AI tools like GitHub Copilot to generate code based on previous inputs, speeding up the development process.
Impact on Development Practices	Improving Code Quality	Accuracy, Error Detection, Code Improvement	AI tools detect errors in real time, ensuring higher-quality code and reducing the number of bugs in production.
	Full Automation Confidence	AI Reliability, Human Intervention, Confidence in AI	USA engineers show higher confidence in AI's ability to fully automate code generation and bug fixing, while Pakistani engineers remain cautious.
	Limited Automation in Pakistan	Manual Coding, Human Judgment	Pakistani engineers still prefer manual coding, particularly for complex tasks, indicating limited reliance on AI for full automation.
	Complexity of Development	Problem-Solving, Complex Algorithms	AI tools help simplify certain aspects of development but cannot yet handle highly complex tasks, which still require human expertise.
Cultural and Operational Challenges	Resistance to Change	Traditional Practices, Resistance to AI, Manual Methods	Cultural resistance in Pakistan comes from long-standing reliance on traditional methods of development and skepticism towards AI-driven tools.
	Lack of Resources	Infrastructure Gaps, Training Gaps	In Pakistan, inadequate resources for AI tool integration—such as lack of infrastructure and proper training—limit AI adoption.
	Openness to AI in the USA	Innovation, Willingness to Adopt AI	The USA is more open to AI adoption, with a greater willingness to invest in AI tools and resources for development.
	Ethical Concerns and Bias	Job Displacement, Bias, Transparency, Ethics	USA engineers express concerns about the job displacement caused by AI and algorithmic bias in AI-generated code. The lack of transparency in decision-making also raises ethical questions.
	Fear of AI Replacing Humans	Automation vs. Human Expertise	Despite embracing AI, engineers in the USA fear that over-reliance on AI may displace jobs and reduce the need for human expertise.
Training and Resources	Lack of Proper Training	Training Programs, Skill Development	In Pakistan, engineers report challenges with AI adoption due to limited access to training resources and a steep learning curve.
	Resource Constraints in Pakistan	Budget Constraints, Tool Accessibility	Financial constraints in Pakistan hinder the ability to purchase and implement advanced AI tools, delaying widespread adoption.
	Availability of AI Resources	Infrastructure, Tool Accessibility, Training Programs	The USA benefits from more accessible AI resources, including advanced training and high-performance computing systems, enabling smoother integration of AI tools into development processes.

Main Theme	Sub-theme	Code(s)	Description
AI Adoption Across Countries	AI Maturity in the USA	AI Integration, Leading Edge, Full Adoption	Engineers in the USA have advanced integration of AI tools, benefiting from well-established infrastructure and robust industry support.
	Developing AI Adoption in Pakistan	Early Stages, Initial Challenges	Pakistan is still in the early stages of AI adoption, with many engineers encountering barriers in fully integrating AI into their workflows.
	Infrastructure Differences	Technological Gaps, Resource Availability	Disparities in technological infrastructure between the two countries affect the adoption of AI tools, with the USA being ahead due to better access to computing resources and research funding.
Ethical and Social Implications	Job Displacement	Automation, Workforce Reduction, AI Impact	There are concerns about job displacement in the USA, where engineers fear that AI-driven automation might eliminate certain roles traditionally held by humans.
	Algorithmic Bias	Fairness, Ethical Concerns, Code Bias	Both countries acknowledge concerns regarding bias in AI algorithms, which might perpetuate existing stereotypes and unfair practices in code generation.
	Transparency in AI	Decision-Making Process, Transparency, Ethical AI	Engineers in both countries express concerns about AI's lack of transparency, which could undermine trust and accountability in AI-driven decisions.

Theme 4: Training and Resources

Training and access to resources are critical factors in AI adoption in both countries. In the USA, engineers benefit from comprehensive training programs and advanced AI tools, which enable them to fully integrate AI into their workflows. Respondent 5, a Senior Developer from the USA, noted, "*There are numerous resources available to help us get up to speed with AI. We have workshops, online courses, and hands-on training that make AI adoption seamless.*" The availability of resources and training has accelerated AI adoption in the USA, making it easier for engineers to utilize AI tools for complex tasks.

In contrast, engineers in Pakistan face significant training gaps and resource constraints, which have limited the widespread adoption of AI tools. Respondent 3, a Project Manager from Pakistan, highlighted, "*We don't have enough training programs for AI. Most of the engineers here are not familiar with advanced AI tools, which slows down the process of adoption.*" This reflects the lack of infrastructure and access to AI training resources in Pakistan, which creates barriers to fully integrating AI into the SDLC. The absence of sufficient training resources and AI tools in Pakistan prevents engineers from gaining the skills necessary to maximize the potential of AI technologies (Raza, Soomro, Khan, & Iqbal, 2025).

Theme 5: AI Adoption Across Countries

The rate of AI adoption is significantly higher in the USA than in Pakistan. Engineers in the USA have embraced AI-driven solutions to automate various stages of the SDLC, while engineers in Pakistan are still in the early stages of integration. The USA's technological infrastructure, investment in AI research, and availability of skilled professionals have enabled quicker adoption and more effective use of AI tools. Respondent 12, a Lead Developer from the USA, commented, "*In the USA, AI is already integrated into our daily tasks. We rely on AI for almost every part of the SDLC,*

from bug fixing to deployment." This demonstrates the USA's leadership in AI adoption, where the integration of AI into development processes is more widespread and efficient.

In Pakistan, however, AI adoption remains limited due to resource shortages, cultural resistance, and insufficient training. Respondent 7, a Senior Developer from Pakistan, remarked, "*AI tools are still in their infancy here. We're starting to use them for basic tasks, but we can't yet rely on them for critical aspects of development."* This slow pace of AI adoption in Pakistan highlights the technological gap between the two countries and the barriers that engineers in Pakistan face in fully utilizing AI tools (Rehmat, Hassan, Rumaan, & Abrar, 2025).

Theme 6: Ethical and Social Implications

The ethical implications of AI adoption are a central concern for both Pakistani and USA engineers, with a particular focus on job displacement and algorithmic bias. In the USA, engineers have expressed concerns about automation leading to job losses in the software engineering field. Respondent 12, a Lead Developer from the USA, stated, "*There's a growing concern that AI will eventually replace human developers. The efficiency it brings is great, but it raises questions about the future of human work in software development."* These concerns are reflective of broader ethical debates around automation in the workforce, with many engineers questioning the long-term social impact of AI adoption.

Additionally, algorithmic bias remains a significant ethical issue in both countries. AI tools, if not carefully developed, can perpetuate biases found in training data, which may result in unfair or discriminatory outcomes. Respondent 5, a Senior Developer from the USA, emphasized, "*AI can replicate the biases of the data it's trained on. If not monitored carefully, AI-generated code can perpetuate unfair practices in development."* This concern underscores the need for ethical oversight in the development and use of AI tools to ensure that they promote fairness and transparency (Shah, Hussain, & Ebrahim, 2025).

DISCUSSION

The findings of this study highlight significant differences and similarities in the adoption and integration of generative AI tools in the Software Development Life Cycle (SDLC) across Pakistan and the USA. The USA shows a more advanced integration of AI tools, while Pakistan faces cultural resistance and resource limitations. These findings are consistent with previous studies that explore AI adoption in different contexts, emphasizing the role of infrastructure, training, and cultural factors in shaping AI implementation.

One notable finding from this study is the confidence in AI's ability to automate various stages of the SDLC in the USA, as opposed to the more cautious approach in Pakistan. This aligns with the research of Ain et al. (2025), who discussed how AI-driven methodologies are already being incorporated in the USA's tech industry, which benefits from better infrastructure and greater resources for training engineers. In Pakistan, however, the training gaps and technological limitations make full adoption of AI tools a challenge. As highlighted by Siddiqui et al. (2020), the lack of advanced infrastructure in developing countries such as Pakistan contributes to the slow pace of AI adoption, making it difficult for engineers to fully embrace AI tools and integrate them into their workflows.

The speed and efficiency brought about by AI tools in both countries were evident, with USA engineers reporting significantly higher productivity and confidence in AI. This finding is in line with Akbar et al. (2025), who noted that AI tools reduce manual intervention and speed up development cycles by automating repetitive tasks like bug fixing and code generation. Engineers in the USA, supported by a more developed technological ecosystem, could rely on AI tools to handle a larger portion of the SDLC, thereby freeing up their time for more complex tasks. In contrast, Pakistan's engineers still experience limited automation, relying heavily on manual coding, particularly for complex development tasks such as system design and algorithm creation.

Cultural resistance in Pakistan, identified in this study, further compounds the challenges of AI adoption. Respondents in Pakistan indicated a reluctance to abandon traditional development methods, which corroborates the findings of Rehmat et al. (2025), who emphasized how cultural factors and familiarity with established methods act as barriers to AI adoption in the tech industry. Engineers in Pakistan fear that the shift towards AI could disrupt well-established workflows and lead to job displacement.

In the USA, however, while openness to AI is higher, ethical concerns about job displacement and algorithmic bias were significant. As Shah, Hussain, and Ebrahim (2025) noted, AI adoption in the USA is accompanied by concerns about job losses and bias in AI algorithms, which could affect the fairness and transparency of the SDLC. Similarly, our study found that engineers in both countries were wary of the potential consequences of AI biases, particularly in automated decision-making processes.

The resource gap between the USA and Pakistan is another theme confirmed by previous studies. Aleem et al. (2016) highlighted that lack of resources and access to cutting-edge tools are key obstacles for AI adoption in developing countries. Pakistan's engineers struggle to gain access to the latest AI tools and training, which limits their ability to effectively implement AI-driven solutions in their development practices.

In conclusion, the findings of this study resonate with existing research on AI adoption in software engineering. While the USA leads in integrating AI into the SDLC, the challenges in Pakistan reflect broader issues of resource constraints, cultural resistance, and training gaps that hinder full AI integration. These findings suggest that addressing these challenges will require improved access to AI resources, comprehensive training programs, and strategies to overcome cultural resistance in order to foster a more widespread adoption of AI in the global software engineering industry.

CONCLUSION

This study examined the integration of generative AI tools into the Software Development Life Cycle (SDLC) across Pakistan and the USA, highlighting key differences in AI adoption between the two countries. In the USA, engineers report extensive use of AI to automate various stages of development, including code generation, bug detection, and testing. This has resulted in faster development cycles and higher-quality outputs, as AI tools reduce the need for manual intervention in repetitive tasks. The greater adoption of AI in the USA is attributed to well-established infrastructure, comprehensive training programs, and a culture of innovation that

encourages experimentation with new technologies. Engineers in the USA are confident in AI's ability to fully automate certain tasks, increasing productivity and enabling them to focus on more complex aspects of software development. In contrast, AI adoption in Pakistan remains limited, primarily due to cultural resistance, inadequate infrastructure, and a lack of access to training resources. Engineers in Pakistan express hesitation toward fully embracing AI tools, particularly for complex coding tasks. While AI tools help automate basic tasks like error checking, developers in Pakistan still rely on manual coding for more intricate aspects of the SDLC. This reluctance is rooted in long-standing familiarity with traditional development methods and a fear of job displacement due to automation. The findings underscore the importance of improving access to training programs, resources, and infrastructure in developing countries like Pakistan, as well as fostering a cultural shift toward greater acceptance of AI to unlock its full potential in software development.

THEORETICAL AND PRACTICAL IMPLICATIONS

The theoretical implications of this study contribute to understanding the role of generative AI in the Software Development Life Cycle (SDLC) across different cultural and technological contexts. The research highlights how AI adoption is influenced by various factors, including infrastructure, resources, and cultural attitudes. In the theoretical framework, the study underscores the necessity of integrating technological maturity, cultural adaptability, and training availability as key components for successful AI integration in software development. By comparing Pakistan and the USA, the study expands existing knowledge on AI adoption in developing versus developed countries, emphasizing the importance of contextual factors in shaping AI-driven transformation in the tech industry.

Practically, the findings suggest actionable recommendations for organizations in both developed and developing countries. For companies in Pakistan, there is a need for investment in AI training programs and improved infrastructure to facilitate smoother AI integration. This includes ensuring access to advanced AI tools and fostering an open culture that encourages experimentation and learning. For the USA, while AI adoption is more advanced, attention should be paid to addressing ethical concerns such as job displacement and algorithmic bias. Companies should implement transparent AI models, ensuring fairness and accountability. The study also emphasizes the importance of balancing automation with human expertise to maintain a sustainable workforce while leveraging AI advancements.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study is limited by its small sample size of 20 engineers, which may not fully capture the diverse perspectives across the software engineering community in both Pakistan and the USA. The focus on only two countries further restricts the ability to generalize findings globally. Additionally, the study primarily relied on semi-structured interviews, which may introduce subjectivity. Future research should aim to include a larger, more diverse sample from multiple countries to better understand how cultural, economic, and technological factors influence AI adoption in the SDLC. Longitudinal studies could explore the long-term effects of AI tools on software engineers' careers, job displacement, and the changing dynamics between AI and human roles in development. Furthermore, examining the ethical challenges of AI adoption, such as algorithmic bias and the impact on diversity in development teams, would provide deeper insights into how these issues can be addressed in different contexts.

DECLARATIONS

Acknowledgement: We appreciate the generous support from all the contributors to the research and their different affiliations.
Funding: No funding body in the public, private, or nonprofit sectors provided a particular grant for this research.
Availability of data and material: In the approach, the data sources for the variables are stated.
Authors' contributions: Each author participated equally in the creation of this work.
Conflicts of Interest: The authors declare no conflict of interest.
Consent to Participate: Yes
Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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