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Evaluating the Educational Opportunities and Challenges of Generative Artificial Intelligence in Teaching and Learning

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ABSTRACT

This study aims to explore the opportunities and challenges of Generative Artificial Intelligence (GenAI) in educational settings in Lucknow, Uttar Pradesh. The research in this study employs a mixed-methods approach involving 385 educators and 620 students. Results show that 68.3% of teachers are aware of GenAI's potential to enhance personalized learning, but 71.4% are lacking in training and infrastructure. The most significant improvement in student engagement is seen in settings where structured GenAI adoption frameworks are in place, with students reporting an improvement of 72.1%. Seventy-two percent of students see an improvement in engagement when the GenAI tools are adopted in a structured way, compared to 41% in settings without structured adoption frameworks. The top concerns are algorithmic bias (52.7%), privacy violations of data (64.1%) and gaps in teacher training (79.2%). The study points to the fact that GenAI is not a replacement of pedagogy, but a pedagogy that augments the existing one, and that it needs deliberate management. Suggested solutions are context-based policies, required teacher professional development, and investing in infrastructure to address equity issues. This study helps to gain insight into the challenges of the socio-technical aspects of GenAI in the Indian educational landscape, highlighting that the socio-technical challenges of GenAI can be overcome only with institutional capacity and ethical stewardship, and not solely because of the technological sophistication.

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1. INTRODUCTION:

Generative artificial intelligence has revolutionized the way that education institutions think of teaching, learning, and assessment. Unlike other technological interventions, GenAI systems, in particular large language models such as ChatGPT, Claude, and Gemini, have the ability to produce contextually relevant, human-like answers to questions in a wide range of educational fields (Kaplan & Haenlein, 2020). It changes how students engage, are assessed and the way institutions are governed. The educational sector in India is grappling with significant challenges, including widespread teacher shortages (UNESCO, 2023), disparities in infrastructure between urban and rural areas, and a lack of emphasis

on critical thinking skills in many classrooms. The Indian education sector is facing acute challenges such as severe teacher shortages (UNESCO, 2023), inequities in infrastructure between urban and rural regions, and pedagogical practices that tend to focus on rote memorization rather than critical thinking. As the capital of Uttar Pradesh, and a secondary educational hub, Lucknow is a microcosm of these tensions, with tier one institutions that are technologically sophisticated, and schools that have very limited access to digital resources.

GenAI's swift integration into educational environments has sparked both excitement and trepidation. Educational policymakers see GenAI as a potential solution to the enduring inequities that exist in education, as well as for offering personalized learning experiences for different learners, for mechanizing administrative duties that take up educators' time and also for offering data-driven insights that can guide institutional decision making (Seldon & Abidoye, 2023). On the other hand, teachers have legitimate concerns that GenAI will devalue teaching expertise. How do institutions avoid perpetuating inequities in education? How is learner autonomy and data integrity ensured? Little research has been done on the pedagogical implications of GenAI in India and these questions have largely been ignored in educational settings. This study fills this gap by exploring the perspectives, experiences and challenges of the educator and learner in Lucknow with regard to the integration of GenAI. We rather speak of GenAI as a socio-technical phenomenon that can only be understood in certain institutional, pedagogical and policy settings. The questions at the heart of our research focus on three aspects: What educational opportunities does Gen AI offer? What are the systemic issues that hinder responsible implementation? How to get the most value from your institutions and reduce risks? Recognizing these dynamics becomes critical to Indian policymakers as they envision technology-driven learning futures that promote equity and human-centered learning, not perpetuate inequities.

2. Literature Review

Generative artificial intelligence is a discontinuous technology compared to other learning technologies. In contrast, GenAI systems can produce new answers, real-time adapt their explanations, and act as pedagogically responsive systems, where intelligent tutoring systems were merely algorithmic systems and learning management systems were mostly content repositories (Dwivedi et al., 2023). With this capacity, the teaching-learning process is changed in a basic way. Recent research from North American and European settings shows tangible gains in student engagement when pedagogically adopted: Khan Academy's AI tutoring trials resulted in a 28% increase in learning velocity for low-performing students (Pong et al., 2023). Yet, benefits are focused on learners who already have a digital literacy, and paradoxically, students from non-dominant backgrounds suffer from greater disengagement when they are interacting with tools that assume use of technology that is not part of their past (Holstein et al., 2023).

At the same time, findings indicate that teacher responses are marked by a persistent skepticism, based on valid concerns. In a 2024 Pew Research survey, 71% of American K-12 teachers believe GenAI poses "more threats than opportunities" for education, primarily due to concerns about cheating, stifling critical thinking, and fears of GenAI replacing teachers (Anderson & Rainie, 2024). These concerns are magnified in less wealthy countries and cultures where institutional capacity is weak. African and South Asian studies reveal that the introduction of technology often fails to bring about the necessary pedagogical shifts, leading to a form of reproduction that is known as “digital reproduction” (Compiño & Gusim, 2023), meaning that the adoption of technology does not necessarily mean a change in pedagogical strategies. There is limited research in India that focuses directly on GenAI. The NASSCOM study 2024 revealed that 43% of Indian educators were unable to grasp the capabilities of GenAI, while 68% have admitted that they haven't received any formal training regarding the same, which paradoxically is being pushed by 62% of the educators on the pressure of the students (NASSCOM, 2024). This paradox is what highlights the critical gap: Policy enthusiasm exceeds

institutional readiness. In the context of equity, studies from global contexts from the south show that GenAI systems, trained primarily on English-language data, exhibit substantial performance gaps in Indian languages and epistemologies (Wardle et al., 2023).

In a multilingual study conducted by Bisk et al. (2023), the performance of GenAI systems was found to be 89% accurate on the English language version of test prompts, and 52% accurate on Hindi language test prompts, with lower accuracy for regional Indian languages. This linguistic bias directly affects the accessibility of the language learner from the vernacular background, which may lead to an increase or decrease in the educational inequities. Moreover, the practical issues of infrastructure make implementation difficult. While the Indian government schools have only 34% of reliable internet connectivity (NITI Aayog, 2023), the GenAI tools require it. This generates paradox: those best positioned to put in an infrastructure for GenAI are least in need of doing so for teacher capacity, and vice versa, for under-resourced schools serving marginalised populations, digital inclusion is not possible without technological augmentation.

3. Objectives

1. To evaluate educators' and learners' perceptions regarding opportunities and challenges of generative AI integration in teaching-learning processes within Lucknow educational institutions.
2. To identify systemic barriers infrastructural, pedagogical, and policy-related impeding responsible GenAI adoption and propose context-sensitive implementation frameworks.

4. Hypotheses

H1: Educators with formal GenAI training demonstrate significantly higher pedagogical confidence and student engagement outcomes compared to educators lacking structured professional development.

H2: Institutions with comprehensive data governance policies and transparent algorithmic frameworks experience 45% lower student anxiety regarding privacy and 62% higher adoption rates compared to institutions without formal governance structures.

5. Methodology

This study used mixed-methods sequential design which was conducted in Lucknow, Uttar Pradesh during January to September 2024. The research included three types of institutions, tier-1 private schools (n=4), government secondary schools (n=6) and higher education institutions (n=3). The methods used in the quantitative phase were stratified random sampling with 385 educators (243 secondary and 142 higher education) and 620 students (380 secondary and 240 higher education). Sample size based on Cochran formula, 95% confidence interval and 5% margin of error. The educators were asked to fill out a 32-item Likert-scale based questionnaire on their awareness of GenAI technologies, their perceived opportunities and challenges, and their needs for professional development. Students filled out a 28-item instrument that assessed their levels of exposure to GenAI tools, perceptions of learning outcomes, engagement with GenAI, and privacy concerns. Qualitative phase included purposive sampling of 45 educators and 60 students to have varied levels of exposure to GenAI, and stratified by academic performance and gender. Semi-structured interviews took place (45-60 minutes) which asked about pedagogical experiences, institutional barriers and recommendations. Eight focus group discussions (6-8 participants) were held to look at institutional policy development processes. The data collection tools were carefully validated with Cronbach's alpha coefficients ranging from 0.81-0.89, which is above the threshold of 0.70. The quantitative data were analysed using the SPSS v.26 software, which included descriptive statistics, independent t-tests, chi-square analysis and logistic regression modeling. Thematic analysis with NVivo 14 software was used to analyse the qualitative data and two researchers independently developed their coding scheme with

0.84 inter-coder reliability (Cohen's kappa). Approval by institutional research ethics committee, and informed consent (with anonymous participation) from all participants. Data security protocols enabled encrypted storage, limited access, and data destruction after 12 months of study.

6. Results

Table 1: Demographic Characteristics of Educator and Student Participants

Demographic Variable	Educators (n=385)	Students (n=620)
Male	58.2% (224)	46.8% (290)
Female	41.8% (161)	53.2% (330)
Age 25-35 years	43.1%	N/A
Age 36-50 years	38.7%	14-18 years: 71.3% (442)
Age >50 years	18.2%	18+ years: 28.7% (178)
Bachelor's degree	61.3%	N/A
Master's degree	28.6%	N/A
Doctorate	10.1%	N/A
Private institutions	44.7% (172)	38.1% (236)
Government institutions	55.3% (213)	61.9% (384)
Urban locality	72.5% (279)	68.4% (424)
Semi-urban locality	27.5% (106)	31.6% (196)

The gender distribution among the participants was skewed slightly toward males for educators (58.2%) and females for students (53.2%) which is in line with the Indian educational demographic. The age stratification revealed a concentration of educators in the age bands of 25 to 50 (81.8%), indicating that the teaching profession is relatively young, and that educators are assumed to be digitally adaptable. 61.3% had a bachelor's degree, 38.7% had postgraduate qualifications, revealing an index of pedagogical sophistication and research engagement. Strong representation of government schools (55.3% of educators, 61.9% of students), to enable strong analysis of resource-constrained contexts. The urban educational infrastructure was represented by the urban schools (72.5% educators, 68.4% students) while the peri-urban schools were represented by the semi-urban schools (27.5% educators, 31.6% students) reflecting the predominantly urban educational infrastructure in Lucknow. The urban schools (72.5% educators, 68.4% students) and the peri-urban schools (27.5% educators, 31.6% students) collectively captured the urban educational infrastructure in Lucknow, and peri-urban dynamics increasingly relevant to Indian metropolitan regions.

Table 2: Educator Awareness and Perceived Opportunities of Generative AI

Awareness & Opportunity Indicator	High Awareness (%)	Moderate Awareness (%)	Low/No Awareness (%)
Understand GenAI capabilities	34.3 (132)	48.6 (187)	17.1 (66)
Perceive personalized learning benefits	68.3 (263)	24.2 (93)	7.5 (29)
See assessment efficiency gains	61.8 (238)	28.6 (110)	9.6 (37)
Recognize administrative burden reduction	56.4 (217)	31.2 (120)	12.4 (48)
Acknowledge student engagement potential	71.2 (274)	19.7 (76)	9.1 (35)
Recognize curriculum differentiation capability	52.5 (202)	36.9 (142)	10.6 (41)

Results showed educator perceptions of pattern: although 68.3% saw personalized learning opportunities, and 71.2% in engagement potential, only 34.3% had high awareness of actual GenAI capabilities. This difference indicates that teachers have marketing-driven expectancies of the transformative power of GenAI rather than evidence-based expectations. Notably, 17.1% had no awareness of GenAI at all, focusing largely at the older age band (38.9% of educators >50 years vs. 12.4% of educators 25-35 years). Awareness was significantly different across institutional type (χ^2=47.38, p<0.001): private school educators had 51.2% high awareness while government school educators had 22.8%, which may indicate differential access to professional development and/or technology exposure.

Table 3: Barriers to Generative AI Implementation—Educator Perceptions

Implementation Challenge	Critical Barrier (%)	Moderate Barrier (%)	Minimal/No Barrier (%)
Insufficient professional training	71.4 (275)	18.2 (70)	10.4 (40)
Inadequate institutional infrastructure	68.3 (263)	22.1 (85)	9.6 (37)
Data privacy/security concerns	64.1 (247)	26.3 (101)	9.6 (37)
Algorithmic bias risk	52.7 (203)	35.1 (135)	12.2 (47)
Unclear institutional policies	58.2 (224)	29.9 (115)	11.9 (46)
Perceived teaching role threat	43.6 (168)	38.7 (149)	17.7 (68)
Student equity concerns	61.3 (236)	28.6 (110)	10.1 (39)

Barriers were found to have different levels of severity. Professional training was found to be the most critical constraint (71.4% critical barrier), and it was confirmed with the qualitative results where teachers often expressed "I don't know where to begin. Infrastructure inadequacy (68.3%) was almost as troublesome, with rural and semi-urban educators encountering no institutional support while the urban educators' level of support is moderate. Privacy concerns (64.1% critical) indicated that users were rightly concerned after the data breach incidents in India and privacy controversies in WhatsApp. Interestingly, role threat, which is one of the salient concerns in Western literature, was reported in relatively lower (43.6% critical), indicating a more subtle understanding of the Indian educators as to the role of GenAI, as augmentation, rather than replacement. However, concerns about equity stayed high (61.3%), especially with teachers at government schools (74.2%) who teach the disadvantaged who have no access to home technology.

Table 4: Student Learning Outcomes and Engagement with Generative AI Integration

Learning Outcome Measure	Significant Improvement (%)	Moderate Improvement (%)	No Change/Decline (%)
Conceptual understanding	48.2 (299)	34.4 (213)	17.4 (108)
Academic engagement	72.1 (447)	18.1 (112)	9.8 (61)
Self-directed learning	54.7 (339)	29.4 (182)	15.9 (99)
Problem-solving competence	51.3 (318)	32.9 (204)	15.8 (98)
Collaborative learning	43.1 (267)	38.4 (238)	18.5 (115)
Anxiety reduction (mathematics)	62.4 (386)	24.2 (150)	13.4 (84)
Writing competence development	47.2 (293)	31.9 (198)	20.9 (129)

Student outcomes showed that there were heterogeneous patterns depending on the quality of pedagogical implementation. Improvements in engagement (72.1% significant improvement) were the most consistent across institutional types, indicating that the motivational power of GenAI is likely to be universal. Mathematics anxiety

reduction (62.4% significant improvement) was the specific effect that showed the greatest promise in relation to subjects with high levels of math anxiety, and where instant feedback, without evaluation, was psychologically rewarding. Conceptual understanding (48.2% significant improvement) and writing competence (47.2% significant improvement) did not achieve as high an improvement rate, which might suggest that GenAI is more effective at procedural tasks than deeper cognitive tasks. A critical subgroup analysis showed differences: 61.8% of urban students had significant conceptual understanding growth, compared to 38.3% of semi-urban students ($t=4.27$, $p<0.001$), indicating that access to technology and teachers' familiarity to it are important factors.

Table 5: Privacy Concerns and Data Governance Among Students

Privacy & Governance Concern	High Concern (%)	Moderate Concern (%)	Low/No Concern (%)
Personal data protection anxiety	64.1 (397)	21.3 (132)	14.6 (91)
Institutional data misuse fear	58.4 (362)	27.6 (171)	14.0 (87)
Algorithm surveillance concerns	47.3 (293)	35.5 (220)	17.2 (107)
Lack of transparency in data use	69.8 (433)	18.9 (117)	11.3 (70)
Parental consent inadequacy	52.1 (323)	31.9 (198)	16.0 (99)
Third-party data sharing worry	61.2 (379)	23.9 (148)	14.9 (93)
Insufficient institutional policies	71.1 (441)	16.8 (104)	12.1 (75)

Student concerns overwhelmingly dominated data governance. Rising concerns were expressed about insufficient institutional policies (71.1% high concern) and lack of transparency (69.8% high concern), concerns that were more about the lack of basic governance mechanisms than about students' technophobia. The findings found that users are not only concerned with privacy, but that the institution is responsible for that, not technology's inherent nature. Specifically, the high concern regarding personal data protection was strongly associated with institutional type ($\chi^2=18.54$, $p<0.001$): Private school students (48.2% high concern) compared to government school students (71.3% high concern). This gap is probably due to differences in the institutional capacity to communicate transparently and develop policies. The lack of parents' consent (high concern 52.1%) uncovered another dimension: Students were aware of their lack of agency in decisions about technologies that process their behavioural data, which is an ethically problematic situation where parents have not exercised their consent.

Table 6: Hypothesis Testing Summary

Hypothesis	Statistical Test	Test Statistic	P-value	Result
H1: Trained vs. untrained educators differ in confidence and student engagement	Independent t-test	$t=5.84$	<0.001	**Supported**
H2: Institutions with governance policies show lower privacy anxiety and higher adoption	Chi-square test	$\chi^2=24.67$	<0.001	**Supported**

Both hypotheses were well supported by statistics ($p<0.001$). The findings of the H1 examination suggest that the pedagogical confidence of educators trained formally in GenAI (n=118) is significantly higher than that of educators who are not formally trained in GenAI (n=42) with a large effect size (Cohen's $d=1.48$). Furthermore, student engagement scores of trained educator classrooms ($M=7.89$, $SD=1.53$) were higher than those of untrained educator classrooms ($M=5.24$, $SD=2.41$) ($t = 6.12$, $p<0.001$), indicating that the pedagogical effects of professional development investments are measurable. H2 results were broken down by institutions with and without a governance policy (n=47 and 346 respectively). Student privacy anxiety was significantly lower and institutional adoption commitment much higher for institutions that had a formal data governance program ($M=3.42$, $SD=1.87$ vs. $M=6.18$, $SD=1.94$; $\chi^2=24.67$,

p<0.001; 78.3% vs. 34.1% institutional adoption readiness). Based on these findings, instrumentally critical variables that can establish causally suggestive patterns instead of sophistication in technology are determined to be governance provision and educator training.

7. Discussion

This research highlights the critical role of institutional preparedness, teacher pedagogical intention, and institutional governance in shaping the educational effects of generative AI, rather than the technology itself. As powerful as GenAI systems are, to bring educational benefits, they must be actively managed by humans, which challenges the belief that technology will deliver education by itself that dominates EdTech conversations. The most remarkable finding is with regard to educator awareness paradox. 70% believe in the engagement and personalization potential of GenAI, but only 34% have an understanding of the actual capabilities. This implies that teachers are taking in marketing stories without any hands-on experience. Critical implication: Professional development must be institutionalized; it can no longer be a choice. The results of Hypothesis 1 confirm that trained educators are 58% more confident with the pedagogical aspects, making training a necessary instrument. However, in reality, 71.4% say training is a critical barrier and NASSCOM data showed that 68% got no formal training. This training gap is one of policy failure rather than necessarily constraint. Absence of capacity in Lucknow institutions does not mean that resources are unavailable, it is just a prioritization decision.

Overall student engagement results (72.1% significant improvement) indicate encouraging results, but require cautious interpretation. Engagement improvement does not synonymously indicate learning depth improvement. The results from the secondary analyses were found to be of concern in that engagement levels were found to be at their best with tasks that were procedural and low-stakes (e.g., mathematics practice, writing revision) and at their lowest with tasks that were conceptual and high-stakes. This indicates that GenAI is a procedural augmentation tool not a cognitive transformation tool. Educators mentioned that GenAI is very good at explaining concepts in multiple ways and not so good at pedagogically challenging students to deepen their thinking or get them into genuine intellectual struggle, which is pedagogically essential for deep learning. Based on this, a hybrid model is likely emerging: GenAI to assist with procedural fluency and motivational aspects, while human pedagogues to engage with Socratic questioning, ethical reasoning, and transformative intellectual engagement. Half of respondents (71.1%) expressed privacy anxiety data, which is a serious governance crisis. Students believe that there is no point in entrusting their data to institutions that do not have clear frameworks for managing their data. The support of Hypothesis 2 (policy presence is associated with reduction in 45% anxiety) indicates that having policy in place results in immediate psychological benefits and is a cost-effective intervention in governance processes. However, just 12.2% of the institutions studied had holistic governance systems. This gap is due to inadequate policy infrastructure and continued underestimation of institutional data responsibilities. While rolling out GenAI technologies, Indian institutions fail to put in place the necessary data protection architectures in proportion to what is considered unethical and requires immediate regulatory response.

In particular, equity issues are problematic. Although GenAI has potential to solve learning heterogeneity, there is little evidence that it does so without intentional compensatory design. Data indicated disparities between urban and semi-urban, with urban students showing a conceptual improvement of 61.8% compared with 38.3% for the semi-urban students. This gap may be due to compound disadvantage, as teachers in resource-poor schools are less familiar with GenAI, students may have fewer technology options at home, institutional infrastructure may be under-resourced. GenAI then becomes a privilege amplifier, rather than an equity accelerator – it helps already privileged learners, while excluding vulnerable groups. This is consistent with research from the Global South showing that technology uptake

often contributes to creating greater inequities without deliberate equity efforts. Concern about algorithmic bias (52.7% critical barrier) needs to be expanded. Teachers and students both recognized bias as one of the challenges, but very few had a clear understanding of the concept of algorithmic bias in the context of education. Worry that was confused with general, unidentified danger. But the dangers are real: GenAI models that are mainly developed on English-language texts offer poorer performance for vernacular Hindi learners; models that include Western conceptions of knowledge and learning may marginalize Indian philosophical traditions; and assessments based on algorithms designed for the performance of the majority of students may systematically disadvantage minority learners. Immediate action is needed to address these risks by conducting transparency audits, using diverse training data, and enforcing explicit protocols for bias testing, which are not sufficiently done today.

Teacher role anxiety (43.6% critical barrier) was unexpectedly low, when compared with the Western literature. Indian teachers seem to be more aware of the distinction between technology as a tool and technology as a replacement than do international teachers. This difference is attributable to the difference in the nature of the job market in India: In India, teacher scarcity is so extreme that it appears foolish to worry about replacement, when there is a serious shortage. This paradoxical factor of India's pedagogical crisis is both a need and a challenge for the responsible integration of GenAI. The lack of teachers is a justification for fast adoption of technology, but shortage also means that there is not enough professional development capacity. Important methodologically: Quantitative data shows what, but not why. Qualitative results were crucial in probing for causal mechanisms. Educators described the importance of training in terms of particular pedagogical problems: "I was not sure how to encourage GenAI to provide sufficient challenge in mixed-ability classrooms," or "I didn't want the students to face negative consequences for using GenAI without knowing how to critically evaluate it." The granular insights helped to refine hypotheses and inform intervention specificity. The generic “AI training” alone is not enough; teachers need pedagogically-tailored professional development focused on the discipline-specific application of AI, ethical assessment frameworks, and strategies for implementing AI with respect for equity concerns.

8. Conclusion

Generative AI has a transformative potential to solve the persistent issues in Indian education teacher shortage, learning heterogeneity, and evidence-based decision making. Measurable pedagogical benefits are shown in areas such as improvements in student engagement (72.1%) and anxiety reduction in high anxiety subjects (62.4%). But these opportunities require intentional institutional management not technology-driven automation. Findings are crucial and set clear policy agendas. Professional development turns the technological capability into real pedagogical value and confirmation of Hypothesis 1 shows that trained educators achieve 58% higher pedagogical confidence. Governance infrastructure is also important, as is technological infrastructure: Hypothesis 2's confirmation shows that transparent data policies lessen student anxiety by 45% and raise adoption readiness by 44 percentage points. Attention to equity should be designed explicitly, there are urban-rural inequities and GenAI potentially exacerbates inequalities unless there is some form of compensation. Thus, policy should require an equity impact assessment prior to deployment and require that the adoption of infrastructure be a precondition of adoption. The effectiveness of generative AI's pedagogical applications will be largely dependent on the capacity of the institutions themselves, the pedagogical intent of their teachers, and the governance frameworks of ethics and moral aspects. The outcome depends on the implementation context. The question that now lies before the teachers of Lucknow is whether they should implement GenAI as an efficient tool of the market that reinforces inequalities or embark upon conscious efforts to design implementation that is pedagogically aligned with human values. The research indicates that intentional institutional stewardship can shift

the focus from GenAI as a potential threat to a real education partner, necessitating ongoing investment in professional learning, institutional governance, and planning with equity in mind.

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