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Ensuring Inclusive and Equitable Quality Education and Promoting Lifelong Learning Opportunities for All: An Analysis Based on Gender Parity Index and Digitalisation in School Education in North East India

Dr. Sarmita Guha Ray[1], Souvik Mukherjee[2]

[1]Faculty, Department of MBA (Finance & Operation), University of Calcutta
[2]Research Scholar, HRDC (Economics), University of North Bengal

Abstract
The key targets of SDG 4 focus on ensuring that all girls and boys complete free and quality primary and secondary education, increasing skills for employment among youth and adults, and eliminating gender disparities in education. Sustainable development involves meeting present demands without compromising the needs of future generations. Quality education is essential for all, particularly vulnerable groups such as poor youth, rural children, persons with disabilities, indigenous peoples, and refugees. Education fosters intellect and self-respect, paving the way for community contributions and prosperity.In Northeast India, the Gender Parity Index (GPI) shows variations in gender equality in education, influenced by digitalisation efforts. Data from the Unified District Information System for Education (UDISE+) reveal that states like Manipur, Meghalaya, and Mizoram demonstrate lower gender inequality in literacy and other indicators. At the same time, Tripura, Assam, and Sikkim face more challenges. Despite progress indicated by UDISE data on digitalisation and GPI analysis, disparities persist, highlighting the need for targeted interventions to confirm equitable access to education for all.

Keywords: SDG 4, Gender Parity Index, UDISE+, School education, North East India, ICT-enabled teaching,

Introduction

Gender parity and digitalization in school education are crucial for equitable educational opportunities. As digital technologies increasingly permeate academic environments, their intersection with gender parity is crucial for the development of inclusive policies. Despite initiatives in countries like Bangladesh and Malawi, significant challenges in reducing gender-based discrimination persist (Chisamya et al., 2012). In Uganda, community partnerships have been established to address these issues; however, traditional gender roles persist, often confining women to household duties (Muweesi et al., 2023). Current measurements of gender parity, often based on school enrollment, overlook broader institutional factors that sustain inequalities, necessitating more comprehensive assessments (Unterhalter, 2015).

In Peru, female students reported greater digital skills, while males excelled in basic navigation, underscoring the need for inclusive digital literacy programs (Huatay et al., 2023). The transition to digital learning has also highlighted disparities in digital reading skills between genders (Kuhn et al., 2021). In Northeast India, gender disparities significantly impact women's access to education and their representation. While progress has been made in states like Meghalaya and Mizoram, rural women in states such as Arunachal Pradesh and Manipur face significant barriers (Mahanta & Nayak, 2013; Hussain, 2025). Political participation remains low for women, with notable disparities across states (Ahmed, 2020).Digitalization aims to enhance learning experiences in Northeast India, integrating e-learning and empowering learners with IT skills (Borgohain et al., 2020). An inclusive digital literacy framework has been proposed to support vulnerable populations in rural areas, emphasizing digital inclusion through mobile technology and tailored curricula (Nedungadi et al., 2018).This paper examines the impact of Digitalization in school education on gender parity in North East India.

Literature Review

There is a relationship between gender parity and digitalization in school education, as digitalization can reflect and influence gender disparities. The research highlights several aspects of this relationship:
Digital Gender Gap

- Higher Education: Digitalization in higher education often reproduces existing gender inequalities. Female students may face challenges in digital reading skills and practices, which are influenced by social inequalities and gendered reading practices (Kuhn et al., 2021).
- University Education: In Spain, the digital gender gap affects women's educational empowerment and leadership. However, transforming teaching methodologies can help close this gap and empower women (Palomares-Ruiz et al., 2021).

Digital Skills and Competence

- Rural and Secondary Education: In Moldova, while no significant gender differences were found in some digital skills, girls outperformed boys in digital content creation and safety (Bărbuță & Ghețău, 2023). Similarly, in Peru, females reported higher competence in digital skills, such as online safety and problem-solving, while males excelled in basic navigation (Huatay et al., 2023).

Influence of Digitalization

- Young Adults: Digitalization tendencies are influenced by gender, with women showing a higher inclination towards using digital technologies. This tendency is also positively correlated with higher levels of education (Markoc, 2024).

Regional Insights

- Latin America: The gender digital divide in education is a significant issue, necessitating further research from both pedagogical and gender perspectives to address these disparities (Ancheta-Arrabal et al., 2021).

Overall, digitalization in education can highlight and exacerbate gender disparities; however, it also presents opportunities to address these gaps through targeted interventions and inclusive educational

practices. Addressing the digital gender gap necessitates a multifaceted approach, encompassing adjustments in teaching methodologies and ensuring equitable access to technology.

Objectives of the study

Keep in mind the goal of SDG 4; this study attempts :

1. To quantify the linear dependence of the Gender Parity Index on the data from computers and digital Initiatives, as presented in the report on the Unified District Information System for Education Plus, in the context of the Northeast Indian states.
2. To make an intercomparison of the impact of all the dimensions on the data of computers and digital Initiatives as presented in the report on the unified district information system for education plus, as mentioned above, on the Gender Parity Index.

Data collection

The analysis draws on data from the report on the Unified District Information System for Education Plus (UDISE+) for the 2023-24 academic year and the All-India Survey on Higher Education (AISHE) for the 2021-22 academic year. The All-India Survey on Higher Education 2021-22 provides data about the Gender Parity Index (GPI) in higher education (18-23 Years) for all categories. The Gender Parity Index is calculated from the data collected through AISHE. The Gender Parity Index (GPI) denotes parity between girls and boys. A GPI of 1 implies parity between the sexes; a GPI that ranges between 0 and 1 typically signifies a disparity in favour of males.

In contrast, a GPI greater than 1 connotes a disparity in favour of females. Eliminating gender disparities in education would help improve the status and capabilities of women. As well as, Unified District Information System for Education Plus (UDISE+) 2023-24 showcases the data of computers and digital Initiatives like functionality of Desktops/PCs, Laptops/Notebooks, Tablets, PCs with functional Integrated Teaching Learning Devices, Projector, Digital Boards/ Smart Boards/ Virtual Classrooms/ Smart TV, Mobile phone, Digital Library. Here, only the northeastern states were considered when selecting data.

Research Methodology

The analysis depends on simple linear regression models. A simple linear regression aims to forecast the value of a dependent variable based on an independent variable. The substantial the linear relationship between the independent and dependent variables, the more precise the prediction. This goes along with the fact that the more significant the proportion of the dependent variable's variance that the independent variable can explain, the more accurate the prediction. Undisguisedly, the relationship between the variables can be exhibited in a scatter plot. The more prominent the linear relationship between the dependent and independent variables, the better the data points represent a straight line.

The following equation can describe the regression line:

$$\hat{y} = bx + a + \in$$

Here, $\hat{y}$ is estimated dependent variable

b is the gradient of the straight line

x is the independent variable

a is the point of intersection with the y-axis

$\in$ is the residual or error parameter

The regression coefficient b can have different signs, which can be elucidated as follows

- $b > 0$: positive correlation between x and y (the greater x, the greater y)
- $b < 0$: negative correlation between x and y (the greater x, the smaller y)
- $b = 0$: There is no correlation between x and y

Analysis and interpretation

Linear regression has been utilized in the analysis. The data on computers and digital Initiatives in the Unified District Information System for Education Plus (UDISE+) 2023-24 has been categorized into five categories: management, Government, government-aided, Private unaided, and others. Therefore, five different linear regression models have been built, considering the aforementioned categories of schools, to assess their respective impacts on the Gender Parity Index.

Residuals:

1	2	3	4	5	6	7	8	9
0.1095796	-0.0872	-0.0896	-0.0283	-0.012 06	-0.0078	-0.00275	0.11886 5	0.000245

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.0850	0.0345	31.4540	0.0000	***
Schools with functional.Tablets.availability_Government	0.0000	0.0000	2.0350	0.0975	.
Schools. Having.PCs.with with functional.Integrated.Teaching.Learning.Devices_Government	0.0027	0.0007	3.6220	0.0152	*
Schools having functional.Projector.availability_Government	-0.0008	0.0002	-3.6360	0.0150	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.09252 on 5 degrees of freedom
Multiple R-squared: 0.7747, Adjusted R-squared: 0.6396
F-statistic: 5.732 on 3 and 5 DF, p-value: 0.04492

Table 1

Table 1 illustrates the impact of computer availability and functionality on the gender parity index in government schools across northeastern Indian states.

Residuals:

1	2	3	4	5	6	7	8	9
0.1328	0.2013	0.01442	-0.09208	-0.07851	-0.18883	-0.01201	0.02248	-0.00001

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.0262	0.0718	14.2960	0.000	***
Schools with functional.Laptop.Notebook.availability_Private_Unaided	-0.0007	0.006	-1.2410	0.2700	
Schools having functional.Projector.availability_Private_Unaided	0.0018	0.012	1.4540	0.2060	
Schools, having functional Smart Classrooms used.for teaching.with.Digital.Boards..Smart.Boards..Virtual ..Classrooms..Smart.TV.availability_Private_Unaided	-0.0009	0.006	-1.3960	0.2220	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1478 on 5 degrees of freedom
Multiple R-squared: 0.4255, Adjusted R-squared: 0.08083
F-statistic: 1.235 on 3 and 5 DF, p-value: 0.3893

Table 2

Table 2 illustrates the impact of computer availability and functionality on the gender parity index in private unaided schools in northeastern Indian states.

Residuals:

1	2	3	4	5	6	7	8	9
-0.02553	0.08618	-0.00698	0.03355	-0.00544	-0.00808 5	0.000302	-0.00124	0.0000

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.3055	0.0611	21.3610	0.002	***
Schools.with.functional.Tablets.availability_Government_Aided	0.0689	0.0155	4.4300	0.0214	*
Schools.having.PCs.with.functional.Integrated.Teaching.Learning.Devices_Government_Aided	-0.0990	0.0251	-3.9400	0.0291	*
Schools.having.functional.Projector.availability_Government_Aided	0.0116	0.0039	2.9830	0.0584	.
Schools.having.functional.Mobile.phones.used.for..teaching.purposes_Government_Aided	-0.0145	0.0036	-4.0570	0.0270	*
Schools.having.Digital.Library.availability_Government_Aided	0.0458	0.0110	4.1620	0.0252	*

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07262 on 3 degrees of freedom
Multiple R-squared: 0.9167, Adjusted R-squared: 0.778
F-statistic: 6.606 on 5 and 3 DF, p-value: 0.07556

Table 3

Table 3 illustrates the impact of computer availability and functionality, as well as various digital facilities, on the gender parity index in government-aided schools in northeastern Indian states.

Residuals:

1	2	3	4	5	6	7	8	9
0.0344929	0.063549	-0.03738	-0.02105	-0.14348	0.015186	-0.00033	0.089113	-0.00011

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.9120	0.2296	8.3290	0.0011	**
Schools.with.functional.Laptop.Notebook.availability_All_Management	-0.0009	0.0003	-3.1550	0.0344	*
Schools.with.functional.Tablets.availability_All_Management	0.0002	0.0000	3.6250	0.0223	*
Schools.having.functional.Projector.availability_All_Manegement	-0.0007	0.0002	-3.2190	0.0323	*
Schools.having.Digital.Library.availability_All_Management	0.0036	0.0010	3.6530	0.0217	*

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09464 on 4 degrees of freedom
Multiple R-squared: 0.8114, Adjusted R-squared: 0.6229

F-statistic: 4.304 on 4 and 4 DF, p-value: 0.09325

Table 4

Table 4 presents the impact of computer availability and functionality, as well as various digital facilities, on the gender parity index in schools supervised by management in northeastern Indian states.

Residuals:

1	2	3	4	5	6	7	8	9
-0.01906	0.03211	-0.00445	-0.00013	-0.00168	-0.00487	-0.00072	-0.00124	0.00000

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.17779	0.00143	82.15008	0.000148	***
Schools.with.functional.Laptop.Notebook.availability_others	-0.02229	0.00200	-11.14400	0.007554	**
Schools.with.functional.Tablets.availability_Others	0.02668	0.00799	3.33850	0.077286	.
Schools.having.PCs.with.functional.Integrated.Teaching.Learning.Devices_Others	-0.08466	0.00855	-9.93600	0.009978	**
Schools.having.functional.Projector.availability_Others	0.03337	0.00334	10.03330	0.009789	**

Schools.having.functional.Smart.Classrooms.used.for.teaching.with.Digital.Boards..Smart.Boards..Virtual..Classrooms..Smart.TV.availability_Others	0.020 2	0.004 0	5.045 0	0.037 111	*
Schools.having.Digital.Library.availability_Others	0.067 2	0.008 8	7.607 0	0.016 846	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02685 on 2 degrees of freedom
Multiple R-squared: 0.9924, Adjusted R-squared: 0.9696
F-statistic: 43.59 on 6 and 2 DF, p-value: 0.0226

Table 5

Table 5 represents the impact of the availability and functionality of computers and other digital facilities on the gender parity index in schools in northeastern Indian states that do not fall into the above-mentioned categories (Tables 1 to 4).

Findings and conclusions of the study

In the analysis, we have constructed five different linear regression models to quantify the dependence of the Gender Parity Index (GPI) in higher education (18-23 Years) for all categories on the data of computers and digital Initiatives like functionality of Desktops/PCs, Laptops/Notebooks, Tablets, PCs with functional Integrated Teaching Learning Devices, Projector, Digital Boards/ Smart Boards/ Virtual Classrooms/ Smart TV, Mobile phone, Digital Library as available from Unified District Information System for Education Plus (UDISE+) 2023-24. Concerning tables 1 to 5, it is found that: -

1. In northeast India, implementing computers and other digital facilities in school education is a fruitful initiative to abolish gender disparity in society.
2. For government schools in northeast India, the availability and functionality of tablets and PCs with functionally integrated teaching-learning devices can improve the Gender Parity Index, whereas the availability and functionality of projectors in the classroom contribute adversely to it.
3. For private unaided schools in northeast India, the sole factor contributing to improving the Gender Parity Index is the functionality and availability of projectors in the school education system. Other factors, such as the functionality and availability of laptops, notebooks, and Smart Classrooms (teaching with digital boards, smart boards, virtual classrooms, or smart TVs), contribute adversely to the Gender Parity Index.
4. For government-aided schools in northeast India, the functionality and availability of tablets, projectors, and a digital library contribute favourably to the Gender Parity Index, whereas PCs integrated with teaching-learning devices and mobile phones contribute adversely.
5. For management-supervised schools in northeast India, the functionality and availability of tablets, as well as the digital library, contribute favourably to the Gender Parity Index. In contrast, the functionality and availability of laptops, notebooks, and projectors contribute adversely.

6. For schools that do not fall under the above-mentioned categories in northeast India, the functionality and availability of tablets, projectors, Smart Classrooms (teaching with digital boards, smart boards, virtual classrooms, or smart TVs), and digital libraries contribute favourably to the Gender Parity Index. In contrast, the functionality and availability of laptops, notebooks, and PCs, when integrated with teaching-learning devices, contribute adversely.

To effectively further the prosecution of Sustainable Development Goal (SDG) 4, which concentrates on ensuring inclusive and equitable quality education, the following recommendations can be considered:

A. Strengthen Legal Frameworks and Enforcement:

1. **Adoption and Enforcement of Inclusive Education Legislation:** Adopt laws that recognize the right to inclusive education for all, prohibiting discrimination based on disability and applying accessibility standards to learning environments.
2. **Enforcement of Anti-Discrimination Policies:** Strengthen enforcement of anti-discrimination policies within the education system, including those related to gender, socioeconomic background, and disability.
3. **Accountability Mechanisms:** Establish precise accountability mechanisms for educational institutions and government bodies to ensure compliance with SDG 4 targets.

B. Targeted Interventions and Support:Addressing Equity Gaps: Implement targeted interventions and support mechanisms for vulnerable groups, including persons with disabilities, indigenous peoples, and children in vulnerable situations.

1. **Funding and Resource Allocation:** Ensure adequate funding and resource allocation for inclusive education initiatives, especially for early preadolescence education and vocational training.
2. **Teacher Training and Professional Development:** Invest in training and professional development for teachers, particularly in areas of inclusive education and special education needs.

C. Data Collection and Monitoring:

1. **Data-Driven Decision-Making:** Use data collection and monitoring to track progress towards SDG 4 targets and identify areas where interventions are needed.
2. **Regular Reporting and Evaluation:** Conduct regular reporting and evaluation to assess the effectiveness of implemented strategies and ensure accountability.

D. Collaboration and Partnerships:

1. **Inter-Ministerial Coordination:** Establish robust coordination mechanisms between the Ministry of Education and other relevant ministries, such as those responsible for disability, social welfare, and gender equality.
2. **Community Engagement:** Engage communities, parents, and students in the development and implementation of education policies and programs.
3. **International Cooperation:** Collaborate with international institutions and other countries to convey best practices and learn from their experiences in achieving SDG 4

E. Promote Lifelong Learning and Skills Development:

1. **Vocational and Technical Training:** Expand access to vocational and technical training, particularly for young people and adults seeking employment.
2. **Skills Development Programs:** Implement skills development programs that focus on enhancing non-cognitive skills, such as critical thinking, problem-solving, and communication.
3. **Lifelong Learning Opportunities:** Promote lifelong learning opportunities for all, including adult

education and continuing professional development. By implementing these recommendations, it is possible to effectively prosecute SDG 4 and ensure that all people have access to inclusive and equitable quality education, promoting lifelong learning opportunities for all.

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