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What Explains the Decline in School Enrolment in India after Two Economic Shocks and Covid-19 Pandemic

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Abstract

The school enrolment data published by the Ministry of Human Resource Development (MHRD), now the Ministry of Education (MoE), Government of India, in the annual reports of the Unified District Information System on Education (UDISE, and later UDISE+) show a sharp decline in enrolment from 2016 to 2020 across different levels of education and types of schools. The decline has been much sharper at the elementary levels, particularly in government and government-aided schools.

The data have been analysed using primarily descriptive statistics. For statistical evidence, panel regression models have also been employed, incorporating dummy variables, depending on the nature of the data. In the initial two models, distinct dummy variables were generated for three events: the announcement of demonetisation, the implementation of GST, and the COVID-19 pandemic. Additional four-panel regression models were executed to conduct a more detailed analysis, incorporating various dummy variables corresponding to different combinations of years and types of schools based on the events above.

The decline in enrolment suggests, at first glance, that these economic shocks could cause a decline in enrolment. However, the relationship was not found statistically significant. Similarly, the effect of the Covid-19 pandemic was also not found statistically significant.

Further analysis established a near-perfect positive correlation between the elementary enrolment and the population in the age group relevant to elementary education. However, the population changes did affect the secondary and

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secondary level enrolment. This is possibly attributable to data scarcity, discrepancy, and the need for more data consistency.

Given the study's conclusions indicating that economic shocks and pandemics are not the leading causes behind the enrolment decline, there is the need for a deeper exploration of the wider socio-economic and structural factors influencing education, utilising pertinent data.

Introduction

Data on enrolment at the elementary (classes I to VIII), secondary (classes IX to X) and senior secondary (classes XI to XII) levels from the Unified District Information System on Education (UDISE+), brought out annually by the Ministry of Human Resource Development (MHRD), now the Ministry of Education (MoE), Government of India, shows a sharp decline in enrolment during 2016 to 2019. The decline in enrolment was more pronounced and prolonged at the elementary level and in the government and the government-aided schools. These schools also experienced a decline in secondary and senior secondary enrolments, but only for a short time. Enrolment in unaided private schools depicts an opposite trend. They recorded a significant jump in their enrolment at all levels of education. Counter-intuitively, the COVID-19 pandemic, which led to the prolonged closure of schools, did affect enrolment in government and government-aided schools at any level of education. They recorded a noticeable recovery in their enrolments from 2020. In contrast, the unaided private schools show a sharp dip in their enrolment from 2020.

For all the schools taken together, the total school enrolment fell from 260.60 million in 2016 to 253.11 million in 2017, thus losing 7.6 million students within one year. The decline continued until 2019 when total enrolment plummeted to 248.34 million. Notably, the rate of decrease in enrolment was much sharper in 2017 than in 2018 and 2019. Also, the enrolment figures started showing recovery in 2020. However, even as of 2022, the latest year for which the data are available, the total enrolment in schools at 255.74 million was still short of 4.86 million compared to 2016. The worst affected was elementary education, which accounts for over 76.18 per cent of the total enrolment in school education. Elementary level enrolment dropped from 197.67 million in 2015 to 186.56 million in 2019. In comparison, the secondary and senior secondary enrolment was not impacted as severely. Enrolment at the secondary level declined during 2017 and 2019 but at a slower rate compared to the elementary level, while at the senior secondary level, the decline was experienced only in 2017 (Table 1).

TABLE 1

Total Enrolment in All Types of Schools
(Figures in Millions)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes	**259.47**	**260.60**	**253.11**	**250.99**	**248.34**	**250.97**	**253.80**	**255.74**
Elementary	197.67	196.71	189.89	187.83	184.50	186.56	187.88	188.63
Secondary	38.30	39.15	38.82	38.48	38.33	38.46	39.01	38.53
Sr. Secondary	23.50	24.,73	24.40	24.68	25.51	25.95	26.92	28.58

Year on Year Change in Enrolment in All Types of Schools
(Figures in Percent)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes		**0.43**	**(2.87)**	**(0.84)**	**(1.06)**	**1.06**	**1.13**	**0.76**
Elementary		(0.48)	(3.47)	(1.09)	(1.77)	1.12	0.71	0.40
Secondary		2.20	(0.82)	(0.89)	(0.38)	0.34	1.41	(1.22)
Sr. Secondary		5.25	(1.37)	1.17	3.34	1.73	3.76	61.50

The government and the government aided schools account for a substantial part of the decline in enrolment. **Government schools** experienced a rather sharp decline in their enrolment over a prolonged period, from 2016 to 2020. Even though the enrolment recorded recovery from 2021, the number as of 2022 is still 132.43 million, compared to 144.14 million in 2015. As of 2022, the government school enrolment has recovered to 140.50 million, which is still lower than the 2015 level. Elementary level enrolment in the government schools was more acutely affected, suffering a dent of 14.43 million in 2021 compared to 2015. It peaked at 111.06 million in 2022 but was still 3.64 million short of the 2015 level.

In comparison, secondary level enrolment was less grievously affected and had recovered fully; so by 2022, it had exceeded the 2015 level. In government schools, the senior secondary level enrolment was the least affected. It dipped by 1.59 per cent in 2017 but recovered immediately after and maintained a robust growth rate despite the onslaught of the pandemic (Table 2).

TABLE 2

Total Enrolment in Government Schools
(Figures in Millions)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes	**144.14**	**143.15**	**137.22**	**131.77**	**128.72**	**128.14**	**132.43**	**140.50**
Elementary	118.92	116.92	111.31	105.83	102.67	101.68	104.49	111.06
Secondary	16.91	17.39	17.21	17.03	16.99	17.03	17.65	17.77
Sr. Secondary	8.31	8.84	8.70	8.91	9.05	9.43	10.28	11.67

Year on Year Change in Enrolment in Government Schools
(Figures in Percent)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes		**(0.69)**	**(4.14)**	**(3.97)**	**(2.32)**	**(0.45)**	**3.34**	**6.10**
Elementary		(1.68)	(4.80)	(4.92)	(2.98)	(0.96)	2.76	6.28
Secondary		2.82	(1.03)	(1.06)	(0.21)	0.24	3.63	0.67
Sr. Secondary		6.43	(1.59)	2.46	1.55	4.13	9.06	13.51

Government aided schools also experienced a severe decline in enrolment for an extended period throughout the two economic shocks and the pandemic. They were yet to recover, as enrolment in these schools in 2022 was 3.51 million lower than in 2015. Unlike the government schools, these schools experienced a sharper and prolonged decline in enrolment not only at the elementary level but also at the secondary level. Their enrolment at both levels of schooling has yet to reach the 2015 level (Table 3).

TABLE 3

Total Enrolment in Government Aided Schools
(Figures in Millions)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes	**30.15**	**29.88**	**29.21**	**27.99**	**27.53**	**27.01**	**26.45**	**26.64**
Elementary	15.83	15.31	14.79	13.98	13.66	13.37	12.83	12.86
Secondary	8.47	8.39	8.29	8.03	7.92	7.78	7.71	7.63
Sr. Secondary	5.84	6.18	6.13	5.98	5.95	5.87	5.92	6.16

Year on Year Change in Enrolment in Government-Aided Schools
(Figures in Percent)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes		**(0.90)**	**(2.22)**	**(4.19)**	**(1.64)**	**(1.87)**	**(2.10)**	**0.76**
Elementary		(3.32)	(3.39)	(5.47)	(2.30)	(2.13)	(4.02)	0.22
Secondary		(0.97)	(1.19)	(3.15)	(1.32)	(1.84)	(1.00)	(0.89)
Sr. Secondary		5.78	(0.73)	(2.50)	(0.52)	(1.34)	0.82	4.09

The **unaided private schools** experienced only a slight decline in their enrolment. It declined by 1.43 per cent in 2017 but bounced back immediately, increasing until 2020. In sharp contrast to the government and government-aided schools, unaided private schools also experienced a marginal decline in their enrolment in 2021, which became rather pronounced by 2022 (Table 4).

TABLE 4

Total Enrolment in Unaided Private Schools
(Figures in Millions)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes	**79.27**	**81.75**	**80.58**	**83.31**	**84.12**	**88.91**	**88.09**	**82.45**
Elementary	57.72	59.34	58.36	60.86	61.15	64.99	64.10	58.95
Secondary	12.45	12.90	12.86	12.89	12.89	13.36	13.36	12.85
Sr. Secondary	9.10	9.51	9.36	9.56	10.08	10.56	10.63	10.65

Year on Year Change in Enrolment in Unaided Private Schools
(Figures in Percent)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes		**3.12**	**(1.43)**	**3.39**	**0.97**	**5.69**	**(0.93)**	**(6.40)**
Elementary		2.81	(1.65)	4.28	0.48	6.29	(1.39)	(8.03)
Secondary		3.57	(0.34)	0.30	(0.01)	3.61	0.00	(3.83)
Sr. Secondary		4.51	(1.52)	2.08	5.43	4.75	0.73	0.20

Enrolment in other types presents a peculiar trend. Their enrolment declined by about 1.45% in 2016 but recorded a remarkable recovery in 2017 (4.64 per cent) and 2018 (30.01 per cent). However, they suffered a severe decline in enrolment in 2020, which continued until 2022 (Table 5).

TABLE 5

Total Enrolment in Other Types of Schools
(Figures in Millions)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes	**5.91**	**5.82**	**6.09**	**7.92**	**7.97**	**6.90**	**6.84**	**6.14**
Elementary	5.19	5.15	5.42	7.16	7.02	6.51	6.46	5.77
Secondary	0.46	0.46	0.46	0.53	0.52	0.29	0.29	0.28
Sr. Secondary	0.26	0.21	0.20	0.23	0.43	0.10	0.09	0.10

Year on Year Change in Enrolment in Other Types of Schools
(Figures in Percent)

Level of Education	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
All Classes		**(1.45)**	**4.64**	**30.01**	**0.66**	**(13.40)**	**(0.85)**	**(10.22)**
Elementary		(0.79)	5.37	32.00	(2.00)	(7.18)	(0.86)	(10.64)
Secondary		0.82	0.31	13.40	(0.56)	(44.09)	0.61	(5.62)
Sr. Secondary		(18.76)	(3.69)	14.64	85.68	(77.43)	(4.40)	4.51

Computed year-on-year basis for all schools taken together, nearly 42.74 million students appear to have lost their learning opportunities during the period under study. Critically, the enrolment losses in the government and government aided schools were 67.05 million and 16.34 million, respectively. The aggregate losses appear much less because the enrolment in the unaided-private schools and the other types of schools, respectively, increased by 34.32 million and 6.31 million (Table 6).

TABLE 6

Cumulative Change in Enrolment in Different Types of Schools
(Figures in Millions)

Type of Schools and Level of Education	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Total*
All Schools	1.13	(6.36)	(8.48)	(11.13)	(8.50)	(5.67)	(3.73)	(42.74)
Government Schools	(0.99)	(6.92)	(12.37)	(15.42)	(16.00)	(11.71)	(3.64)	(67.05)
Government Aided Schools	(0.27)	(0.94)	(2.16)	(2.62)	(3.14)	(3.70)	(3.51)	(16.34)
Unaided Private Schools	2.48	1.31	4.04	4.85	9.64	8.82	3.18	34.32
Other Type of Schools	(0.09)	0.18	2.01	2.06	0.99	0.93	0.23	6.31

Note: Figures in (parenthesis) denote decline in enrolment
Source: Compiled and computed by the authors from the UDISE and UDISE+ data

The estimated losses of learning opportunities are an understatement. The change in the enrolment should be computed by calculating the difference between the actual enrolment and the estimated enrolment for each year. In the present case, the changes were computed by calculating the differences between actual enrolment and enrolment in 2015. We could not project the enrolment due to the non-availability of enrolment data before 2015.

It is often seen that data visualisation depicts reality rather mote convincingly than the tabular presentation of data. With this in view, the enrolment data across different types of schools by the level of education has been presented in the form of scatter diagrams with smooth lines through Figures 1 to 4.

FIGURE 1

Total Enrolment in Classes I to XII in Different Types of Schools in India

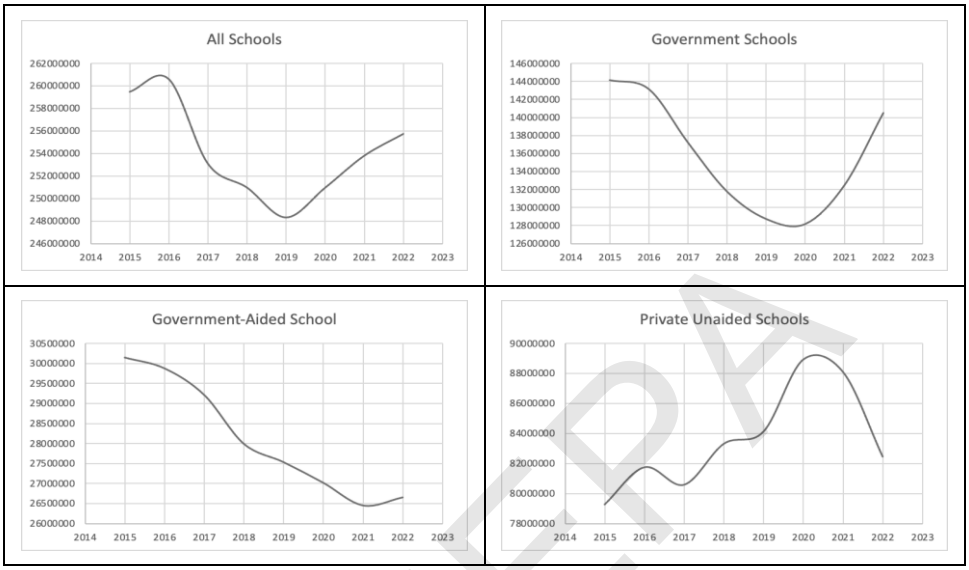


FIGURE 2

Enrolment at Elementary Level (Classes I -VIII) in Different Types of Schools in India

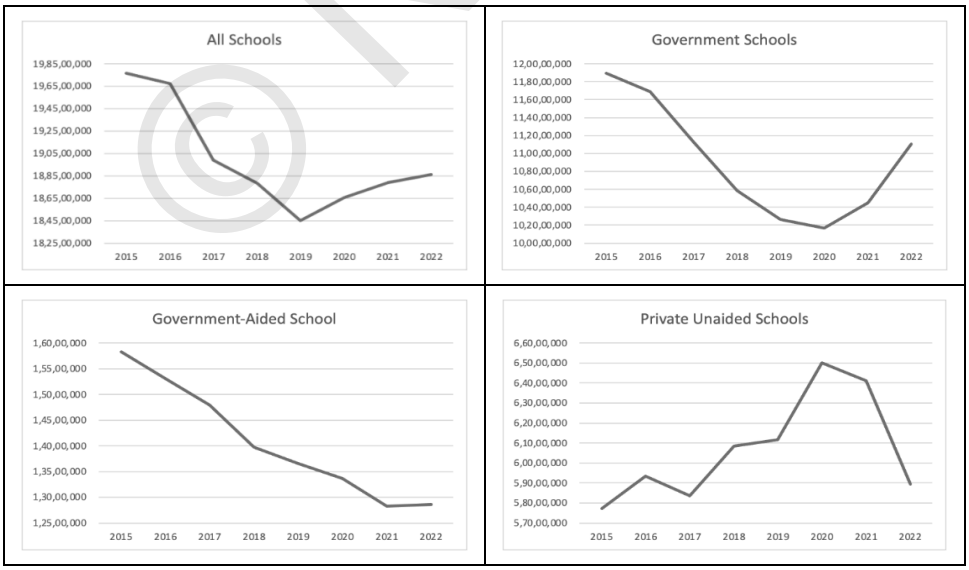


FIGURE 3

Enrolment at Secondary Level (Classes IX -X) in Different Types of Schools in India

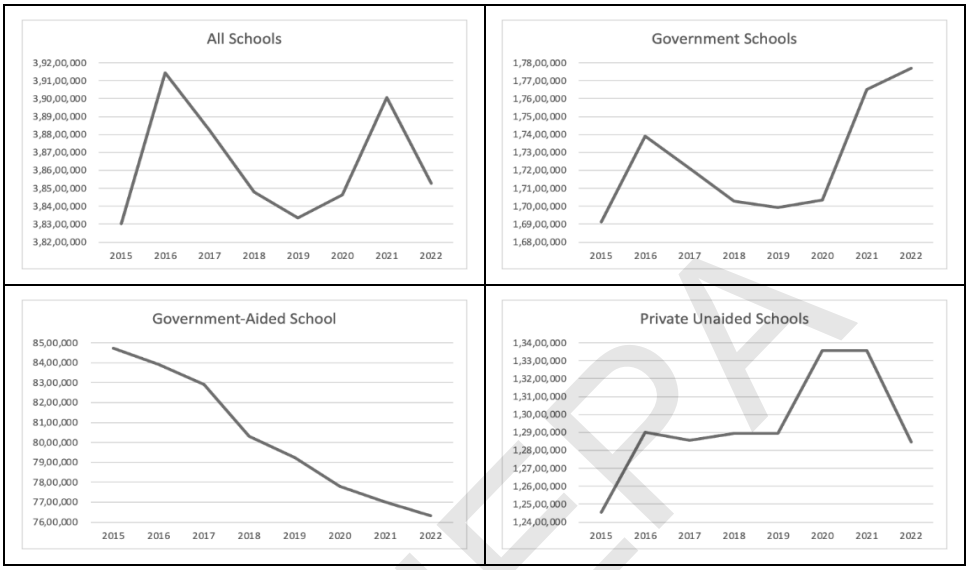
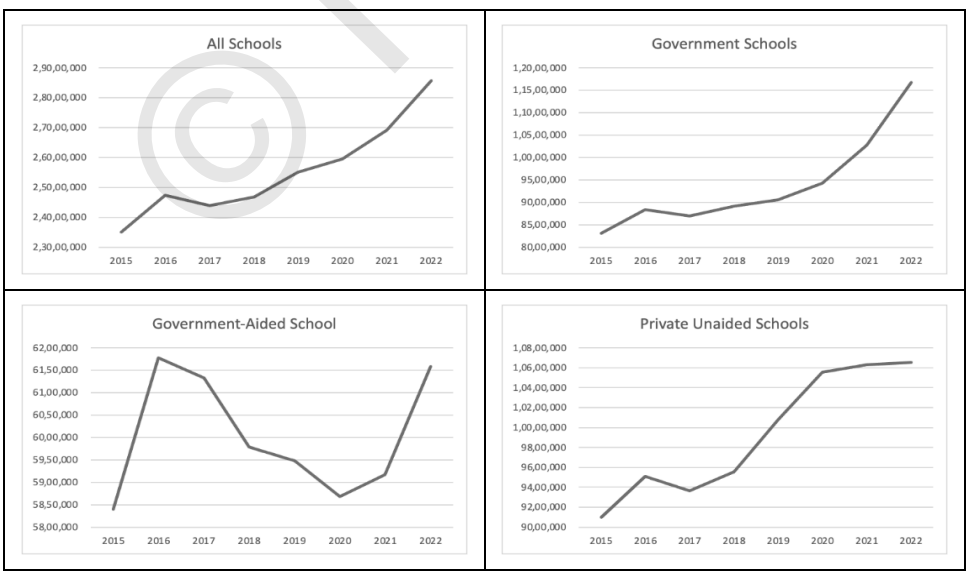


FIGURE 4

Enrolment at Higher Secondary Level (Classes XI -XII) in Different Types of Schools in India



Can the Decline in Enrolment be Attributed to the Economic Shocks and the Pandemic?

The decline in enrolment, as delineated above, coincided with two economic shocks in India — demonetisation in 2016 and GST implementation in 2017 — thereby indicating that these could be the most likely reasons for the loss of learning opportunities for a large number of students, particularly those for whom the government and the government aided schools are the mainstay. Our study thus runs counter to the claim made by ASER (2021), which reported a big jump in the total enrolment in government schools and a sharp decline in the total enrolment in private schools. Contrary to their claim that enrolment in private schools had dropped from 32.5 per cent in 2018 to 24.4 per cent in 2021 and that enrolment in government schools increased by 5.3 per cent (*The Tribune*, 2021), our analysis found a sharper decline in enrolment in the government and the government aided school during the same period.

It is counter-intuitive that the prolonged closure of schools, spanning over 182 days, due to the extended lockdown following the COVID-19 pandemic did not cause as much loss of learning opportunities as the demonetisation and GST implementation. The pandemic did not push as many students out of the school system, probably because the technology came to the rescue and the teaching-learning processes kept continuing, though remotely. Even those who suffered from the loss of life and livelihood in the family could somehow continue. The pandemic may not have led to a decline or deceleration in enrolment. Still, as not everyone could access technology equally, the pandemic must have led to the loss of learning, as has been reported by many researchers in different country settings.

Disruptions unsettle established equilibrium across many sectors of the economy. Economic shocks, natural calamities and pandemics can cause not only the loss of learning but also the loss of learning opportunities. Some disruptions, like the ones caused by technological changes, may be exceptions, for they enhance learning and access to learning opportunities. At times, technological disruptions may be used to mitigate the adverse impacts of disruptions caused by human actions and natural calamities.

The COVID-19 pandemic brought all economic activities to a standstill, causing a significant loss of livelihood and income, affecting the education sector. The complete closure of schools over a prolonged period disrupted children's education. The teaching-learning activities, however, continued remotely by leveraging technology. This ensured that the students were not deprived of access to learning opportunities, even though remote teaching did cause a significant degree of learning loss. Extended lockouts took a toll on a large number of human lives, deprived large sections of society of livelihood and forced many more to migrate out from their place of work.

The worst affected were the deprived and the marginalised sections. This, too, could have adversely impacted the continuation of children's education. These may or may not have been helped by the technology. This happened in most parts of the world, and India was no exception. India, however, suffered two additional disruptions: the abrupt demonetisation of large currency notes in 2016 and the Goods and Services Tax (GST) implementation in 2017. These two disruptions are known to have had cascading effects on various sectors of the economy. The consequent loss of livelihood and income opportunities adversely impinged upon the education of the weak and the vulnerable.

What do Existing Research Studies Suggest?

Extended absence of students from their classes, compelled by circumstances beyond their control or their own volition, absenteeism, in short, affects learning outcomes (Santibañez & Guarino, 2021). School closures due to natural calamities or inclement weather cause learning losses by depriving students of learning opportunities (Andrabi *et al*, 2021; Palacios & Rojas-Velásquez, 2023; Sacerdote, 2012). The school shutdowns due to EBOLA, which led to a decline in enrolment in the affected countries, also caused significant learning losses among the children belonging to the socially deprived classes (Yao *et al*, 2021).

COVID-19 presents a different scenario. It triggered the longest-known lockdown in India, forcing schools to close down for a prolonged period. Nonetheless, the teaching-learning activities were continued online, and the transition to remote teaching was rather swift (Oxfam, 2020), but the intensity and the technology differed significantly across different countries. While the high-income countries resorted to internet-based interactive teaching-learning solutions, the low-income economies had to contend with the low-cost, multi-modal approach. The use of technology significantly arrested the drop in enrolment, but the learning outcomes in the two sets of countries differed significantly (Muñoz-Najar *et al*, 2021).

Even in a highly developed economy like the Netherlands, the prolonged closure of schools negatively affected students' academic performance, and schools with a high proportion of students from disadvantaged groups suffered the most (Maldonado & De Witte, 2022). However, another study in the same country context reported that the closure of schools caused a learning loss of about 3 per cent for all students. In contrast, the learning losses increased exponentially to 40 per cent for students with low parental education (Engzell *et al*, 2021). So was the case with England. A twelve-week closure of schools pushed students eight weeks behind, with the learning deficiencies being more pronounced in the case of socially and economically deprived students (Rose *et al*, 2021). The reported learning losses could be underestimated as most studies assessed only the immediate effect of the pandemic. The losses could be significantly higher in the medium to long term (Kaffenberger, 2021).

Most evidence of the learning losses on account of school closure and absenteeism are from the Western countries, presumably because they have standardised test scores which are readily available, which made it easier for them to compare the pre- and post-pandemic performance. Even though the empirical evidence from less fortunate and underdeveloped countries, including India, may be limited, they all point out that school closures affect all but more so the disadvantaged and the deprived sections. Further, within the underprivileged groups, specific subgroups get more adversely affected. In Malawi, for example, the dropout rate for girls was twice as high as for boys (Kidman *et al*, 2022). Further, the students who were weak in their studies were more susceptible to dropping out. A South African study concludes that students suffered learning deficits, but those with poorer academic backgrounds suffered the most (Berg *et al*, 2020). A survey undertaken in Tamil Nadu, a relatively developed southern state of India, reports that children studying in rural schools experienced higher learning losses than those in urban schools. Further, the learning losses were more pronounced for disadvantaged students (Singh *et al*, 2022).

Demonetisation and GST implementation have been peculiar to India. Their effects on the economy, loss of livelihood and decline in income have been comprehensively studied. However, little explicit evidence exists to show if they affected school education. Their implications may, however, not be difficult to deduce. It is established that the loss of livelihood disrupts the socioeconomic fabric of families, causing economic shocks, which, in turn, impinges on the education of the children of the affected families.

Demonetisation eroded the livelihood for those working in the micro, small and medium enterprises (MSME) and the unorganised and cash-dependent sectors, which account for nearly 90 per cent of the workforce. Job losses in these sectors were manifested by the sudden increase in the demand for MNREGA jobs ((Janardhan, 2017; Shalini, 2017; Wanda, 2017). It is estimated that rural households suffered a loss of about 15.5 per cent in their household income (Zhu *et al*, 2018). The job and income losses also extended to the formal sector due to the in-formalisation of the formal sector (Kumar, 2017). The labour force participation rate declined from 50 to 45 per cent, whereas the overall employment rate declined by one per cent, translating into a loss of 9.5 million jobs (Rose & Shrivastava, 2021).

Crises cause economic shocks, forcing families to withdraw their children from schools (Singh, 2012). Even a temporary economic shock can have lasting consequences (Rose & Shrivastava, 2021). The dropout probability increases significantly during economic shocks (Woldehanna & Hagos, 2015). Further, female students are more likely to drop out and withdraw from school when families face financial crises (Björkman-Nyqvist, 2013; Park & Brown, 2002). Economic shocks caused by failed agriculture, natural calamities, and market disruptions negatively affect children's access to education (Gignoux & Menéndez, 2012; Singh, 2010). A study conducted by using household data from rural India found that the effect of rainfall shocks was more severe in girls than boys (Zimmermann, 2020). So is the case with hardships caused by parental death; children bereaving the death of their mother are less likely to perform well in schools, while the death of their father affects their economic conditions, compelling them to drop out (Case & Ardington, 2006).

While the effect of the pandemic on the loss of learning and loss of learning opportunities are well documented, little evidence is available on the impact of the trio, or the 'triple whammy,' for want of a better vocabulary, on the learning loss or loss of learning opportunities for people. Considering the above, it appeared desirable to analyse the effect of the two economic shocks and the COVID-19 pandemic on school enrolment in India. Quantifying the *learning losses* is difficult, for it requires conducting standardised tests. Measuring the loss of learning of learning opportunities is relatively easy, as a decline in enrolment indicates disruptions in schooling. This, in turn, hinders students' progress and educational development. Quantifying the learning losses in India is equally difficult due to the need for data on children's academic scores in some standardised tests. Thus, instead of assessing the learning losses and deficiencies, the paper aims to examine the effect of the three events on the enrolment of children in different types of schools. Enrolment, a precondition for learning, may be used as a reasonable indicator of access to learning opportunities such that a decline in enrolment would indicate denial or loss of learning opportunities.

Is the Relationship between Crises and Enrolment Statistically Significant?

To test the statistical significance of the variations in enrolment during the study period, the data were subjected to the rigour of the model used for event analysis to ascertain the effect of a significant event. For this purpose, a panel regression model was executed to demonstrate the relationship between the total number of students enrolled at different levels of schools (elementary, secondary, and senior secondary) and the announcement of demonetisation, implementation of GST, and the COVID-19 pandemic. The model encompassed eight periods (from 2015 to 2022) and three cross-sections (elementary, secondary, and senior secondary).

The number of students enrolled at different levels was considered a dependent variable. Four dummy variables were created to represent the independent variables. To capture the impact of demonetisation and the implementation of GST, 2016 and 2017 were assigned a value of 1; similarly, to signify the effect of the COVID-19 pandemic, 2020 and 2021 were assigned a value of 1. Thus, there were four dummy variables (D1, D2, D3, and D4). The purpose was to compare the enrolment data for these years with the rest of the years, but the relationship was not statistically significant in any of the four cases (Table 7).

TABLE 7

Impact of Crisis on Total Enrolment across Different Types of Schools

Variable	*Coefficient*	*t-Statistic*	*Prob.*
Constant	84544892	3.490376	0.0024
D1	2320761	0.042848	0.9663
D2	-175424	-0.00324	0.9974
D3	-887665	-0.01639	0.9871
D4	56594.83	0.001045	0.9992

Further analysis involved an examination of a panel dataset comprising 12 distinct cross-sections and spanning the same eight-year period. These cross-sections encompassed elementary government, secondary government, senior secondary government, elementary government aided, secondary government aided, senior secondary government aided, elementary private unaided, secondary private unaided, senior secondary private unaided, elementary others, secondary others, and senior secondary others. In this case, the impact was insignificant for all four dummy variables. Hence, statistically, there is no impact of demonetisation, implementation of GST, and the COVID-19 pandemic on the number of students enrolled at different levels and different types of schools (Table 8).

TABLE 8

Impact of Crises on Total School Enrolment at Different Level (12 Cross-Sections)

Variable	*Coefficient*	*t-Statistic*	*Prob.*
Constant	21136223	4.658436	0
D1	580190.3	0.057187	0.9545
D2	-43856	-0.00432	0.9966
D3	-221916	-0.02187	0.9826
D4	14148.71	0.001395	0.9989

To conduct a more detailed analysis, 16 dummy variables were introduced, corresponding to different combinations of years and types of schools. D1, D2, D3, and D4 capture government schools' 2016, 2017, 2020, and 2021 data. D5, D6, D7, and D8 represent the data for the same years for government aided schools. Similarly, for the same years, D9, D10, D11, D12, D13, D14, D15, and D16 are for private unaided schools and other schools respectively. Out of 16 dummy variables, only one (D3) was significant with a negative coefficient. This means that the enrolment in government schools in 2020 significantly differs from that of all types of schools in 2015, 2018, 2019, and 2022. The result shows the obvious negative impact of the COVID-19 pandemic on the number of students enrolled in government schools (Table 9).

TABLE 9

Impact of Crises on Different Levels of Education Across Different Types of Schools

Variable	*Coefficient*	*t-Statistics*	*Prob.*
Constant	21136223	69.39846	0
D1	2289768	1.681121	0.0973
D2	313281.5	0.230008	0.8188
D3	-2713453	-1.99219	0.049
D4	-1285770	-0.944	0.3485
D5	599444.4	0.440105	0.6613
D6	378244.7	0.277703	0.7821
D7	-354686	-0.26041	0.7953
D8	-543988	-0.39939	0.6909

Contd…

D9	-180341	-0.1324	0.8951
D10	-568915	-0.41769	0.6775
D11	2207821	1.620957	0.1097
D12	1933279	1.419391	0.1604
D13	-388111	-0.28495	0.7766
D14	-298036	-0.21881	0.8275
D15	-27347.2	-0.02008	0.984
D16	-46926.2	-0.03445	0.9726

To identify the level (elementary, secondary, and senior secondary) in government schools impacted, the panel regression was run separately on the data of elementary, secondary, and senior secondary schools. In the case of secondary and senior secondary schools, all 16 dummy variables are insignificant. Only in the case of elementary schools, D3 is significant. It illustrates the negative impact of the COVID-19 pandemic on the number of students enrolled in government schools at the elementary level.

Furthermore, while exploring other categories, negative coefficient values were observed for 2016 and 2017, albeit statistically insignificant. It can be attributed to potential data scarcity, particularly considering the limited number of data points available before 2016. Thus, demonetisation and GST implementation have had no statistically significant impact on student enrolment across various educational levels. However, descriptive statistics hint at the negative potential impact.

What, Then, Explains the Decline in Enrolment

It has been irrefutably established that the decline in school enrolment could neither be attributable to the two economic shocks nor the COVID-19 pandemic and are independent of them. However, the reduction in enrolment is too large to ignore and must have been caused by some plausible reason. The search led us to the country's estimated population of school-going children in the relevant age groups. People aged 6-13 years were considered relevant for the elementary level of education, while those aged 14-15 and 16-17 years were regarded as relevant to the secondary and senior secondary levels of education. The data on the estimated population in the relevant age group for 2016 and 2018 to 2022 were taken as reported in the UDISE+ annual flash report. In contrast, 2014 and 2015 were taken from the Ministry of Education (MoE) website.

Since a quick data visualisation indicated a consistent decline in the catchment population (Figure 5), Karl Pearson's Coefficient of Correlation (r) between enrolment and the people in the relevant age group was computed at a 95 per cent level of confidence to ascertain if the population affects enrolment. The analysis indicates that the decline in the elementary level of education, which accounts for over 76 per cent of the total school enrolment, strongly correlates with the population in the relevant age group of 6-13 years in the government and the government aided schools. The unaided private schools, however,

present a different picture. The results at the secondary and the senior secondary levels of education across all the different types of schools remain unexplained (Table 10).

FIGURE 5

Changes in School Going Population the Relevant Age Groups

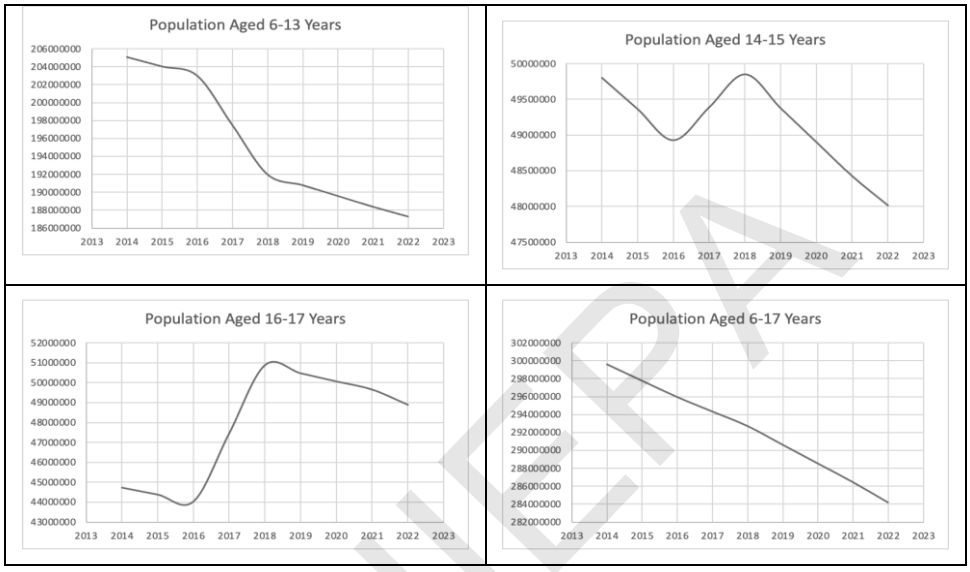


TABLE 10

Coefficient of Correlation at 95 Percent Level of Confidence between Age Specific Population and Enrolment across Different Types of Schools and Levels of Education

Type of Schools	*Elementary*	*Secondary*	*Sr. Secondary*
All Schools	0.893365127	-0.29991285	0.475907457
Government Schools	0.83278612	-0.86536684	0.38092294
Government Aided Schools	0.984477436	0.601839277	-0.258986092
Unaided Private Schools	-0.638459471	-0.349195456	0.622334421

Given the massive dropout of students at the secondary and senior secondary levels, it is understandable that the enrolments at those education levels do not have a significant relationship with the populations in the relevant age group. Further, the correlation coefficient between the total enrolment at all levels of education and the total population of

children in the age group of 6-17 years computed to be 0.41. This is mainly due to the opposite enrolment trend experienced by the unaided private schools.

Besides, as mentioned before, the relevant age-group population reported by the UDISE+ and the MoE are estimates based on the population growth rate applied to the population data from the 2011 census. The possibilities of estimation errors and data discrepancies too may not be ruled out. Notwithstanding the regression analysis between the elementary enrolment and the population in the relevant age group (6-13 years), these show a statistically significant relationship (Table 11)

TABLE 11

Summary Output of Regression Analysis
Elementary Enrolment and Population of 6-13 Year Age Group

	All Schools	*Government Schools*	*Government Aided Schools*	*Unaided Private Schools*
Multiple R	0.893365127	0.83278612	0.98447744	0.638459471
R Square	0.798101251	0.69353272	0.96919582	0.407630496
Adjusted R Square	0.764451459	0.64245484	0.96406179	0.308902245
Standard Error	2299296.52	3879564.69	213038.777	2210447.114
Observations	8	8	8	8
F Statistics	23.71786609	13.5779466	188.778774	4.128813111
Significance F	0.002794096	0.01027162	0.0000092419	0.088424893
Coefficient	0.643176221	0.82110224	0.16812505	-0.257982313
t Stat	4.870099186	3.68482654	13.7396788	-2.031948107
P Value	0.002794096	0.01027162	0.0000092419	0.004136351

Conclusion and Policy Implications

In social science research, the obvious often becomes abstruse and evades the scrutiny it deserves. The economic shocks and the pandemics were such major disruptors in contemporary times that it appeared natural to deduce that the decline and fluctuations in enrolment could be attributable to them alone. On the ground, the argument fell flat. A thorough statistical analysis established that these events had no significant effect on enrolment across various educational levels and types of schools.

It is often seen that data visualisation depicts reality rather convincingly than the tabular presentation of descriptive data or statistical results. Computed year-on-year basis for the government and government-aided schools, nearly 83.4 million students appear to have lost their learning opportunities during the period under study. The decline in

enrolment coincided with three crises in India: demonetisation in 2016, GST implementation in 2017, and the COVID-19 pandemic in 2020 and 2021. This indicates that these could be the most likely reasons for the loss of learning opportunities for many students, particularly those for whom the government and government aided schools are the mainstay. However, as already mentioned, the three events could not be proved to be statistically likely reasons for the loss of learning opportunities.

The decline in enrolment, particularly at the elementary level of education, was too large to ignore, and further investigation was required to identify the reasons. The decline was mainly associated with the fall and fluctuations in the relevant age group population. The reasons for enrolment fluctuation at the secondary and the senior secondary level of schooling transcend numeric values. There is a critical point that a child's prospects hang in the balance behind every statistic. Changes in birth rates, migration, and relocations of families have a bearing on school enrolment, but identifying the right cause is essential to comprehend the issue in the proper context.

It is about students at the crossroads where they are faced with tough decisions regarding their education. They often leave school due to their inability to continue for many reasons. Many discontinue their education because they cannot cope with the academic requirements due to the lack of parental support. Some leave because of economic reasons to take up work to support their families. Others may lose interest simply because they do not feel connected to the school community or do not see the value of education.

What is critical is to realise that each dropout presents a story of individual struggles and obstacles. It is about comprehending these individuals' journeys and devising ways to aid each student. Hence, it is necessary to study additional factors beyond the demographic fluctuations affecting enrolment at these levels.

We need a targeted intervention to address the decline in school enrolment at the elementary level, specifically in the case of government and government aided schools where the correlation with population fluctuation is the strongest. Interventions focusing on enhancing the accessibility of education, mitigating barriers to education, and elevating the standard of education should be looked into by policymakers.

Due to the lack of a significant correlation between population fluctuation and enrolment at secondary and senior secondary levels, further investigating the root cause behind enrolment patterns and dropout rates is pertinent. As data illustrates, the worst affected were the government and government aided schools, and for the deprived and the marginalised sections, these schools are the mainstay. The decline must be probed further for the underlying causes to mitigate the loss of learning opportunities, particularly for these sections.

Efforts to enhance data accuracy and reliability need to be prioritised. This may involve refining methodologies for data estimates and strengthening the data collection process and the monitoring mechanisms.

Since the analysis suggests that economic shocks and pandemics were not the primary drivers for the decline in enrolment, it becomes necessary to investigate further the broader socio-economic and structural elements affecting educational access. This necessitates future research to elucidate the complex interplay of factors shaping educational accessibility using relevant data.

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A Bibliometric Analysis of Work Life Balance in STEM Careers

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Abstract

In recent years, the fast-paced globalisation and modernisation have prompted organisations to prioritise family-friendly work-life balance (WLB) policies. Past literature has focussed on the work-life conflicts prevalent across various professions which show a decreased well-being among workers. There exist many theories on WLB; however, there has been a notable gap in research concerning work-life balance amongst the science, technology, engineering, and mathematics (STEM) workforce. Broadening participation in STEM fields is essential as it enriches innovation and problem-solving, improving the nation's living standards and maintaining global competitiveness. Despite the critical role of STEM fields in driving innovation and economic growth, the demanding nature of these professions often poses challenges for maintaining a healthy balance between work responsibilities and personal life. This paper explores the published literature in order to find out the factors responsible for poor WLB in STEM careers. It uses bibliometric and visual analysis methods to analyse the publications in a systematic way from four databases namely Scopus, Web of Science, Cambridge Core and Sage roughly from 2005 to 2024. It investigates the most influential countries, research organisations, top clusters etc. The results reveal that the USA is the only country which has done a major chunk of research on this topic as compared to the developing nations which are far behind as evident in the cluster analysis. Work-life balance in STEM academia is not just limited to its physical aspects but also 'mental health' which was the topmost, frequently occurring keyword, according to the Cambridge core collection analysis. Furthermore, the paper discusses policy implications for promoting work-life balance in STEM professions, such as implementing flexible work arrangements, parental leave policies, childcare support, and mental health initiatives.

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Introduction

A strong science, technology, engineering, and mathematics (STEM) workforce is vital for every nation, forming the basis for effective employment, immigration, science and technology advancements, education, and national security policies. Acknowledging this significance, government support for nurturing scientific talent has been a consistent focus in policy deliberations. There is a need to promote workplace flexibility and job security to attract more workers into STEM, especially for developing nations, as STEM careers can help them improve their growth rates. Scientific research and related careers often demand long hours and dedication to projects. However, employers in the science sector are acknowledging the need for work-life balance. Policies such as flexible schedules, remote work options, and supportive workplace cultures are being implemented to support scientists. In science careers, prioritising self-care and setting boundaries are crucial for maintaining a healthy balance between work and personal life.

Identifying Gaps in the Study of Work-Life Balance and STEM Careers

Earlier research had stated that there weren't any theories which were universally accepted for WLB and all the existing ones are different in terms of the study's framework, variables and perspectives but it also asserted that the boundary and border theory were the two theories with major foundation which had been used by many researchers to explain the different perspectives of WLB (Muthulakshmi, 2018). The past literature shows that five basic theories had been used to explain the work-life relationship which had been identified by Zedeck and Mosier (1990) and O'Driscoll (1996), namely segmentation, spillover, instrumental, conflict and compensation theories, whereas the border and boundary theory had been proposed by Clark (2000) which were related to balancing work and family together (Bello & Tanko 2020). It had focused only on a small number of theories like the spillover, conflict, segmentation-integration, enrichment facilitation and border theory, leaving the rest. A survey of 234 employees working in four organiSations in Australia, which included a university, private sector firm and two public sector organisations, the results revealed how work to family enrichment and vice versa have a positive relation to self-efficacy which had a positive impact on the WLB (Chan *et al*, 2016). When WLB positively impacts the job and family satisfaction, it is known as the Enhancement theory (Chan *et al*, 2016). The enrichment theory propagates that if one has experience in the work role, it facilitates in improving the quality of other roles in life or vice versa (Chan *et al*, 2016). Theories focussing on mental health haven't been highlighted in the light of mental harassment faced by women in STEM and this study has added this particular dimension as earlier the ideas were mainly focussed on social sciences including sociology, psychology, etc, whereas the latter focusses on work-life balance. Additionally, in contrast to prior decades, the focus of the current research has switched from the work's unpleasant and contradictory features to its beneficial and facilitative characteristics (Khateeb, 2021). Extensive literature exists on WLB theories but there is a need to focus on issues apart from work like cross border issues etc (Thilagavathy & Geetha 2021). The consequences of the work to life conflict are more than life to work and life is more important as revealed in a

survey of 215 STEM post-doctoral trainees (Pitt, Taskin Alp & Shell 2021). More theories are needed in the context of developing nations as there is a dearth of reliable work-family and work-life constructs especially in developing nations like India where family as an institution is very strong and female participation in on the rise.

Methodology

Information on the topic 'work life balance and STEM careers' has been scrounged from four databases which include Web of science, Scopus, Cambridge Core and Sage for conducting a thorough examination of WLB in STEM careers. In the Web of Science Core Collection, we searched for ALL = (Work life balance AND STEM careers), and a total of 48 results appeared for 22 nations from 2007 to 2024 without any filters. All books, editorials, articles, etc, were included. Using Mendeley, we found no duplicate records in the above. The highest papers were in the category of management (6 papers, 13.043 per cent) whereas the lowest were in economics (1 paper, 2.124 per cent). In Scopus, a total of 84 documents appeared after searching for TITLE; ABS; KEY (Work AND life AND balance AND stem AND careers) AND (LIMITTO (LANGUAGE, "English")) from 2008 to 2024 with filters being limited to the inclusion of English language. A total of 70 documents were in English language and only 1 was in Russian which had been excluded. No duplicates were found in the database. All books, editorials, articles etc were included. In the Cambridge Core, we searched for 'Work life balance AND STEM careers' and limited the search to articles and further to Cambridge prisms under the collections which left us with 111 records from 2014 to 2024 for the bibliometric analysis. Cambridge prisms is a series of open access journals. Duplicates were screened in Mendeley and zero records found. In advanced search of the Sage database, after searching for "Work life balance AND STEM careers" and limiting to the subject area of education and research articles from 2005-2024, we found 452 records. Education had been selected in the subject area because the focus was to find out how work and life balance is managed in STEM academia. All the four datasets were exported to VOS viewer software separately to construct, visualise and analyse the bibliometrics.

TABLE 1

Keywords Employed in the Literature Search and the Number of Results for Each Database

Keywords	*Scopus*	*Web of Science Core Collection*	*Cambridge Core*	*Sage*
Work life balance AND STEM careers	84	48	111	452
Duplicates	1	0	0	0
Total (net of duplicates)	83	48	111	452

Results

Web of Science

Co-Authorship and Countries

Among 22 countries, 7 met the threshold with the USA having 987 citations and India with just 1. The USA connected with England, Spain, Australia, and Czech Republic in 2018. India, Sweden, and Spain had no clusters. Developed nations' research focused on women's position in academic science (Ceci *et al*, 2014), the intersection of race or ethnicity and gender of women in STEM and how their career-work life experiences are different from those who fit in with the norms well (Kachchaf *et al*, 2015), WLB and the challenges faced by faculty in STEM to overcome it and their tolerance to facing gender bias in their respective departments (Beddoes & Pawley, 2014; Giakoumi *et al*, 2021; Turner *et al*, 2018;,Minerick *et al*, 2013; Hooker *et al*., 2017); methods for managing the career barriers and employing coping strategies (Amon, 2017; Graves *et al*, 2021; Adamowicz, 2017), research collaboration (Carr *et al*, 2019);, policies for work life balance by the employer and its effect on productivity (Feeney, Bernal, and Bowman 2014); preconceived nations or factors affecting a STEM career (Tan-Wilson & Stamp, 2015; Howe *et al*, 2022). The intervention by an accelerator to improve the WLB by female faculty (Villablanca *et al*, 2013), suggestions to balance the gender ratio in STEM (Barabino *et al*, 2020), work-family conflict (Pitt *et al*, 2021; O'Neal, 2019). Clearly, the developed nations are working on these topics and developing nations like India who have a higher gender imbalance aren't conducting more researches.

In India, a single piece on work existed on the challenges faced by women scientists and engineers and the role that the scientific institutions can play to help them in overcoming it (Kurup and Raj, 2022) and another one focussed on the women entrepreneurs who have emerged as a result of career breaks and dealt with work life balance issues (Sharma, 2022). The entry of women in workforce in USA started in the 1970's whereas in India it happened after the LPG which might be a major reason for the different career trajectories of women in STEM and their current status.

TABLE 2

Co-Authorship and Country, Web of Science

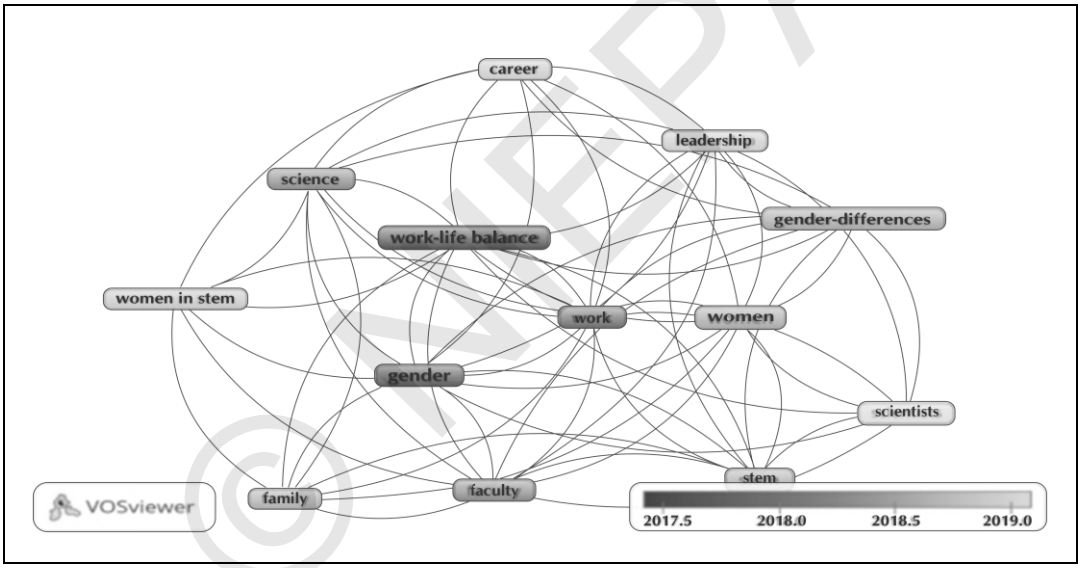
Id	*Country*	*Documents*	*Citations*	*Total link strength*
1	Australia	3	34	6
4	Czech Republic	2	15	3
5	England	2	25	6
10	India	2	1	0
19	Spain	2	23	3
20	Sweden	2	24	0
21	USA	35	987	6

Co-Occurrence and Keywords

Based on co-occurrence analysis, "work-life balance" emerged as the most frequent keyword with 15 occurrences and the highest linkage strength of 82, followed by "women" with 14 occurrences and a total linkage strength of 77. Research initially focused on the integration of work-life balance with gender, career, and leadership in mid-2017, then shifted towards exploring the intersection of women with faculty, STEM, science, and family in mid-2018. By mid-2019, the focus expanded to include scientists and their intersection with women, gender differences, STEM, and faculty. In terms of co-occurrence with a minimum of 5 occurrences, "work-life balance" remained prominent, followed by "women in STEM," "leadership," and "STEM." In keyword plus analysis, "women" had the highest occurrences (11), followed by "gender" (9), both with a minimum of 5 occurrences.

FIGURE 1

Co-Occurrence and Keyword Analysis, Web of Science



Scopus

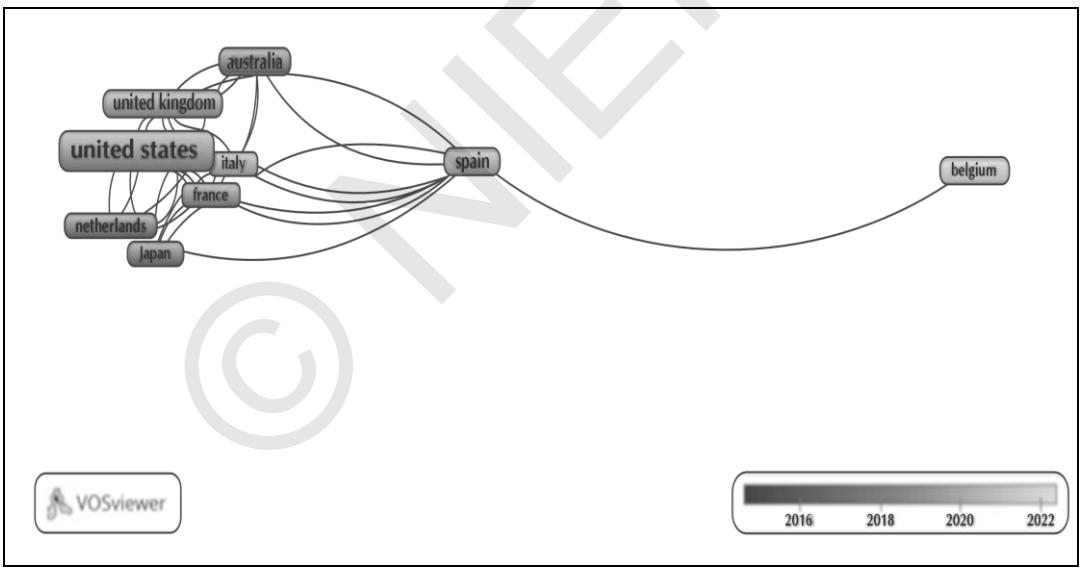
Co-Authorship and Countries

On the basis of co-authorship between countries, out of 31 countries with minimum no. of documents being 2, the USA being an outlier had the highest number of documents (50) with the highest number of citations (1247), with the UK being second with 66 citations and 4 documents. In the bottom was Sweden with 2 documents and zero citations and India with 2 documents and 1 citation. The USA had clusters with five other nations, viz., Australia, France, Germany, Italy, the UK, whereas Sweden had a cluster with Belgium and Spain and India had no clusters. The first cluster had research work focussed on retention of women faculty in STEM by improving the quality of work and life through various support

programmes and it also focussed on inclusion of women of colour, leadership development and team building (Dell *et al*, 2017). The second paper of the two documents talked about the career barriers of women faculty in STEM and how beyond grants an institution can contribute to the retention and advancement of its human resources (Bailey *et al,* 2015). The second cluster focussed on the changes in the institutional formal and informal systems to enhance the participation of women faculty in STEM (Dell *et al*, 2017) and organisational issues that act as a barrier for success of women in their scientific career (Bailey *et al*, 2015). The third cluster in which there is only one country (India) which has 2 documents where the first one focusses on women entrepreneurs who have a STEM background and had taken a career break because of work family conflict and inspire of the hardships are establishing themselves and trying hard to make a place for themselves in a place dominated by men (Sharma, 2022). The other document talks about the role of the scientific institutions in enabling the work life balance of women scientists and engineers as more joint families convert to nuclear ones and the responsibility towards family increases (Kurup and Raj, 2022).

FIGURE 2

The Clusters of Nations Working on This Topic, Scopus
(3 Clusters Identified)



Co-Occurrence and Keywords

"Work-life balance" was the most frequent keyword, occurring 24 times out of 637. Initially, research focused on its intersection with various themes until mid-2017. From 2016-17, attention shifted to the professional aspects in STEM. Co-occurrences with author keywords included "work-life balance" and "STEM" 14 times. With index keywords, "human" occurred 16 times, followed by "female" and "work-life balance" with 14 occurrences each.

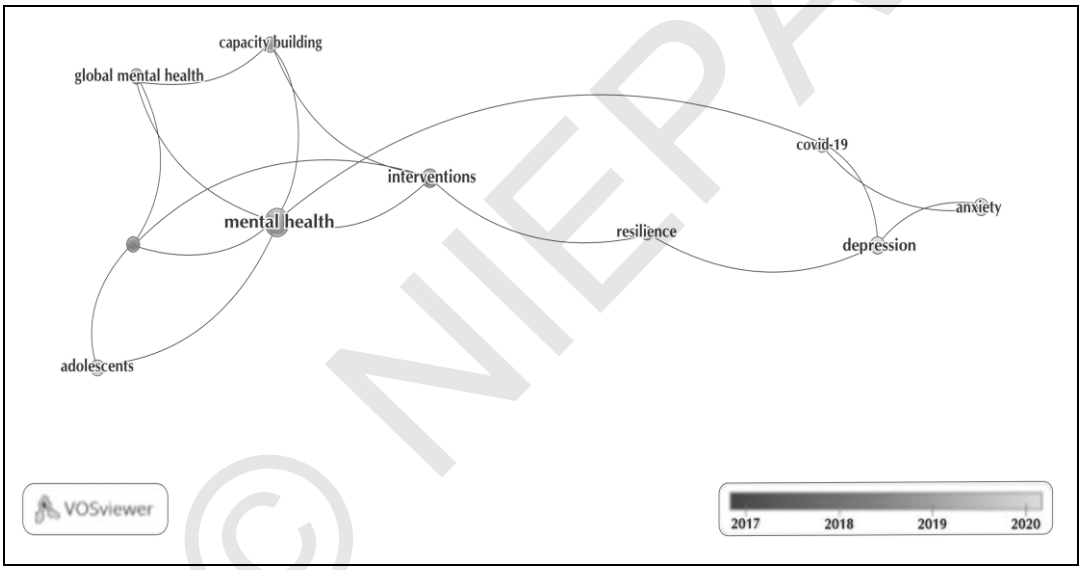
Cambridge Core

Co-Occurrence and Keywords

"Mental health" had the highest occurrences (14) out of 274 keywords, with the highest link strength of 10. "Depression" followed with 8 occurrences and the second-highest link strength of 6, while "interventions" had 7 occurrences and a link strength of 5. "Mental health" was highlighted in 2018, "depression" in 2022, and "interventions" in 2017. Studies in 2023 emphasised gender-related stress and anxiety during the COVID-19 pandemic, particularly among female healthcare workers, including nurses, who faced depression and stigma.

FIGURE 3

Keyword Analysis of Cambridge Core



Sage

Out of 451 authors, only 3 authors had 2 documents each with zero link strength. Bib excel revealed 3 journal articles each by authors "Albert MN" and "Burt BA". The main organisation was *Journal of Transformative Education*, where a journal article titled "Educating the Wandering Mind: Pedagogical Mechanisms of Mindfulness for a Curricular Blind Spot" was published by author "Ergas O". The USA was the only country listed. Sets of authors "Pyöriä P, Ojala S, Saari T, Järvinen KM" and "Albert MN, Dodeler NL, Guy E" collaborated on 2 documents each. The keyword with the highest frequency across all records was "students," followed by "study."

Discussion

The research now has shifted to the consequences and the implications of having a balance between work and the rest of life and more emphasis has been given to organisational psychology in the eastern European nations. (Guest, 2002). The research in 2005 was focussed on the race, merit and people of colour (African nations) that sustained inequity in education and stood against cultural inequities that were a barrier in high quality education (Rogers & Oakes, nd; Brooms & Wint, nd) and in 2006 it shifted to school environment having an effect on the post high school life path (Lindholm, nd), contemplative education in universities in order to bridge the gap between distinctness across ethnic groups, individual differences etc (Holland, nd). In 2008, the focus was on vocational education and training for school students to educate them about their responsibility towards sustainable development and for their empowerment in the developed nations (Arenas, nd) and in 2011 there was research on pedagogies in higher education (David, nd). It was in the year 2013, according to the Sage database, when the research on mental health of Latinos was carried out for the first time as they faced language barriers (Peters *et al*, nd) but the direction of research was again back to the role of vocational training in learning for career and labour market transitions (Barabasch and Merrill, nd), maths faculty and classroom practices (Mesa, Celis, and Lande, nd) in 2014, whereas in Cambridge core it was from 2014 onwards that mental health, maternal and child heath had been focussed upon as resiliencies lead to disordered mood and anxiety (Belkin, 2014; Ahuja *et al*, 2016). In 2015, documents were published on promoting mental health in low- and middle-income countries in (Tol, 2015; Sikkema *et al*, 2015) whereas in 2016, stigma of mental illness (Stuart, 2016; Lora & Sharan, 2015) and treatment of common mental disorders were the topics touched upon (Thomas *et al*, 2016). More research on mental health was carried out in 2018 (Cherry *et al*, nd; Sharma & Razzaque, 2017; Yang *et al*, 2017) and added to it, the effect of gendered norms and violence on the self-esteem among adolescents was also studied (Stark *et al*, 2018; M. T. H. Le *et al*, 2018; Kane *et al*, 2017). In the year 2020, people of colour mainly the black men in STEM in the African nations and their sense of belongingness with their peers had been studied (Burt, Roberson, *et al*, nd). In 2021, several topics were being researched upon in the developing nations like teachers resilience to a professional development program as it was mostly the novice teachers who ready to challenge the existing norms (Tamah and Wirjawan, 2021), developing technical/hard and soft skills (Ochieng and Ngware, nd), students engagement in learning (Teravainen-Goff, nd), the push and pull factors and the socio cultural context for doctoral student to pursue PhD from abroad or the geopolitical equity in global mobility (Oleksiyenko *et al*, nd), the academic professionals in a research university having the burden of research and teaching and which is the only thing they focus thereby, failing to perform administrative work (Lee *et al*, nd), professional development of teachers or pedagogical approaches to correct the gender equity in science (Forte-Celaya *et al*, 2021), inquiry based pedagogical approach in teaching (Post and Molen, nd), maths teaching practices for teachers by providing a framework of teaching pedagogy (Gargroetzi *et al*, nd; Hu *et al*, nd; Post & Molen, nd), traditional teaching methods in Nigeria and other developing countries hinder young people's interest in STEM, making them perceive STEM subjects and careers as inaccessible and this narrow perspective limits their understanding of opportunities in the STEM sector (Dele-Ajayi *et al*, 2021). In 2022, studies were carried on socio cultural adaptation issues

(Yılmaz and Temizkan, nd), black male graduate students facing public shaming and how caring relationships can assist them better in completing their degrees as opposed to their expectation Burt *et al*, nd), Latina students, early career scientists and junior faculty experiencing diverse environments and mentoring programmes needed to take care of the retention and recruitment of this diverse population for them to achieve academic success (Pagan *et al*, nd; Rincón & Rodriguez, nd; Curry & Athanases, nd), more community based partnerships in order to retain the Latin students in STEM (Herrera and Sánchez, nd), teachers consciously or unconsciously getting affected by the gender bias while teaching in classrooms (Vu and Pham, nd), intersectional factors like race and ethnicity making it difficult for the women in the engineering workforce to progress as they didn't feel a sense of belongingness (Wilson and Van Antwerp, nd), university based sports and academic clubs contributing to the development of certain attributes in learners like leadership, communication, resilience, etc (Foley, *et al*, nd), science students after pursuing their bachelor and master's degree choosing a discipline in science according to the narratives ,the expectation of having a particular image attached it and on the basis of cultural and institutional capital (Madsen and Holmegaard, nd), using Latina college students consider cultural wealth to decide career in healthcare as an honour to the women in their family which is critical to achieving equitable systems (Smith, nd), leadership roles of women (Alizadeh *et al*, nd), empowerment of women educators (Calderón, nd; Edwards & Magill, nd; Cipollone *et al*, nd), gender inequalities in STEM careers in developing countries hinder work-life balance, particularly for mothers where challenges include productivity bias post-motherhood, limited promotions, and unequal wages (Gunawan, Mulyadi, and Kustiawan, 2022).

The papers in 2023 studied how grit relates to burnout among academic rheumatologists. It found that higher grit is linked to greater professional efficacy but not exhaustion or cynicism(Miyawaki *et al*, 2023), less self-determined individuals in science showing a stronger inclination to leave later due to perceived lower salary and a lack of work-life balance (Chong, Ahmed, and Amin ,2024), internal factors like sexism navigation, work attitudes/behaviour, stress management, self-concept, work-life-family balance, interpersonal strategies and external factors like social supports, workplace characteristics (Smith 2024), STEM careers can be highly stressful due to pressures like tight programme deadlines, meeting the needs of multiple stakeholders and resolving disputes (Rivera, Elzomor, and Pradhananga, nd), students' gender and race/ethnicity significantly influence their career outcome expectations in diverse ways (Doyle *et al*,. 2023), major challenges in the workplace include career progression, workflow organisation, family life policies, sexism, and gender imbalance, health workers operating in highly stressful environments during the covid pandemic risking their well-being to deliver life-saving services faced difficulties in managing work life balance and in order to mitigate burnout and prevent premature exits from the workforce, it was crucial to prioritise their protection, provide supportive work environments, offer stress management resources, and ensure access to mental health services when necessary (Hoover *et al*, 2023), during the pandemic, over one-fifth of pharmacists in psychiatric hospitals reported experiencing symptoms of depression or anxiety, underscoring the necessity for policy reforms to enhance workplace conditions and promote psychological well-being among this professional cohort (Zhang *et al*, 2023). In the Philippines, individuals reported moderate-to-severe clinical outcomes such as fear, depression, anxiety, or stress during the pandemic. Coping behaviours, including

resilience and various adaptation methods such as religious, spiritual, and community-oriented approaches, were highlighted in response to stringent infection prevention and control measures aimed at containing COVID-19 (Ocampo *et al*, 2024). The research papers published in 2024 were based on pandemic times when offering family-friendly support, including emotional assistance, could ease work-life conflicts for women faculty in computer science, thereby contributing to retention efforts(Lawson *et al*, 2024), burnout among academician attributed to heavy workload, long hours, and inadequate work-life balance (Shakir *et al*, 2024), during the pandemic, poor sleep quality was prevalent at 59.4 per cent and the factors significantly associated with and predictive of poor sleep quality included the use of electronic devices before sleep, increased workload, and distractions while working (Aye and Lee, 2024), healthcare workers (HCWs) mainly women commonly addressed the stigma they faced while carrying out their COVID-related duties and a significant proportion, 77.42 per cent, reported experiencing some form of stigma (Grover *et al*, 2023), Several factors including financial strain, caregiver burden, relationship quality, belief in mental illness, perceived COVID-19 stress, satisfaction with health services, depressive symptoms, anxiety symptoms, and life satisfaction were examined. Results indicated significant correlations between relationship quality among spouses, COVID-19 stress, and caregiver burden with anxiety symptoms, depressive symptoms, and life satisfaction (Cham *et al*, 2024). Careers can be highly stressful due to pressures like tight program deadlines, meeting the needs of multiple stakeholders, resolving disputes, and ensuring the safety of all individuals on site (Beresford and Rose, 2023).

In developed nations, work-life balance in scientific careers varies based on industry, organisational culture, and individual preferences. While there's growing recognition of its importance, challenges like long hours persist despite initiatives such as flexible work arrangements and parental leave policies. In developing nations, especially for women in STEM, work-life balance is poorer and requires measures like flexible hours, childcare support, and reduced workload. Culture is another important factor that hinders WLB of women in STEM careers as in the developing nations, they are expected to do all the household chores by themselves whereas in the developed nations, it falls equally on both the gender. Women are mainly constrained by cultural barriers like domestic care which hinder their progress in STEM. Future research should focus on WLB policies in developing nations, particularly at the intersection of STEM and women. Policy implications include flexible work arrangements, robust parental leave, childcare support, diversity initiatives, mental health resources, workload management, and research funding prioritisation, all aiming to enhance well-being and retention in STEM professions.

Conclusion

Women, STEM leadership and career success has not been understood well especially in developing nations like India where culture plays a major role. The country-wise analysis of all the four databases revealed the USA as the only nation which has done the maximum research on the intersection of women, STEM and workplace. An in depth understanding of the WLB policies for women at their workplace needs to be researched upon. Researchers can study the inter wining relationship between work, family and WLB policies to know the reasons for dwindling no. of women in STEM leadership. Additionally, a broader disciplinary approach is needed on WLB where work organisational psychologists might play an

important role. More research is needed on the intersection of ethnic groups, belongingness and gender not just limiting to physical aspects but mental health in STEM as well. It should also prioritise an examinination of the work-life balance policies in developing nations, particularly at the intersection of STEM and gender. Overall, fostering a culture that prioritises work-life balance is essential for enhancing the well-being, productivity, and retention of STEM professionals, ultimately contributing to a more sustainable and inclusive workforce in the field of science, technology, engineering, and mathematics.

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Exploring the Impact of Educational Data Mining on the Performance of the Student: A Comprehensive Review

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Abstract

Data mining techniques have been implemented in various academic disciplines in order to make meaning of massive datasets; educational data mining my thus be used to increase student performance, retain students, and enhance the quality of education in response to the proliferation of data-related coursework. This paper offers a comprehensive analysis of data mining on the basis of the academic literature. The paper's findings are presented in the form of tabular data and graphical representations. Finally, the conclusion has been stated regarding educational data mining and its probable potential future directions. The long-term survival of the educational data mining applications is dependent on continuous development and the assimilation of the most recent scientific knowledge. The creation of more complex feedback systems and assessment instruments is made possible by educational data mining. Educational data mining makes use of massive datasets produced in learning environments, including feedback, interaction patterns, and student performance. Predictive models can be created that can anticipate students' academic success and identify at-risk pupils who might require extra support is one of the goals of educational data mining and learning analytics. Predictive models can be created so as to foresee the future trends and offer prompt interventions in order to enhance the learning outcomes by evaluating past data on student behaviour and performance.

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Introduction

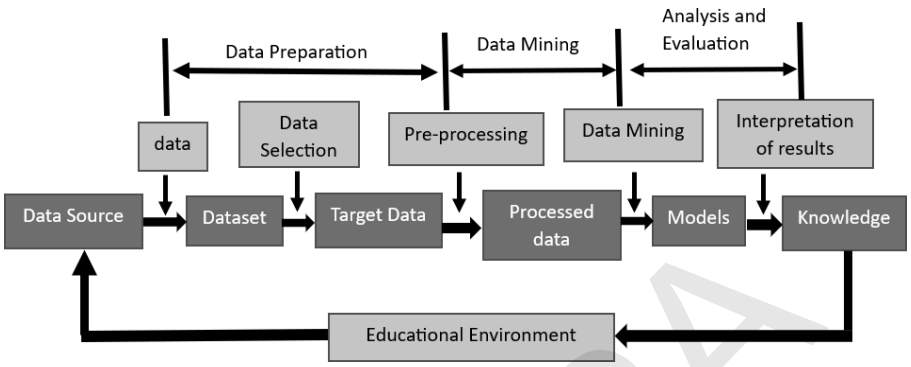
In the contemporary day, information is collected and kept in vast databases. There is an urgent requirement for storing educational data due to the massive amount of material educational institutions generate (Yadav, Bhardwaj and Pal, 2012). To achieve the intended outcomes, what is required is to adhere to a clearly defined procedure for transforming raw data into information and then processing data into knowledge. Because of its interdisciplinary nature, EDM entails the use of data mining (DM), statistics, machine learning (ML), information retrieval (IR), and recommender system approaches on a wide range of educational datasets (Dutt and Ismail, 2020). Universities used to gather a lot of data about their students every year. These data include application specifics, academic performance information (such as school, degree, course path, and exam score), and demographic data (like age, location and socio-economic status) (Yadav et al, 2012). The educational system is greatly impacted by the availability of online training at any time. To save time, it is essential to combine in-depth knowledge with online training. The biggest obstacle to traditional educational approaches is data collection and analysis (Panday and Pal, 2011). Online training platforms allow for the real-time tracking of a multitude of data. It does not provide important information that is needed to make decision regarding learning, like how the data can be transformed into fresh insights (Liand et al, 2016).

Learning Analytics and Educational Data Mining

Any interaction between students and computer-based educational information systems typically leaves a digital footprint that can be analysed alongside other data. In addition to providing students with access to course materials, learning management systems may assist with task administration, evaluation, and reporting of student data, as well as dropout risk prediction tools (Yadav, Bhardwaj and Pal, 2012). Intelligent tutoring systems are computer-assisted learning tools that record and modify the learning environment based on all interactions between students and instructors. Since the information these systems store is linked to specific actions or occurrences, such as the results of task assignments and quizzes, it will be more granular at the course level. In this fashion, Learning Analytics (LA) and Educational Data Mining (EDM) are receiving more attention. Despite sharing a common ground and focussing on distinct objectives, both disciplines are multidisciplinary (Romero and Ventura, 2020). Learning analytics emphasises the collection, analysis and extraction of knowledge from learning-related data to comprehend and optimise learning outcomes and environments.

FIGURE 1

Process of EDM



Artificial Neural Network in Educational Data Mining

In EDM, machine learning — in particular, artificial neural networks (ANNs) — can be very helpful for prediction tasks. The design and operation of biological neural networks found in the human brain served as the paradigm for artificial neural networks, or ANNs. Each connected node, or neuron, in them is arranged in layers, accepting input signals, processing them, and then producing an output signal. How ANNs link to EDM for prediction is as follows.

Pattern Recognition: The ability of ANNs to identify patterns in data is essential for forecasting student outcomes in EDM. Artificial neural networks (ANNs) can be trained on historical educational data to uncover intricate correlations between a variety of variables, including academic achievement, learning patterns, and student demographics. ANNs can forecast future student results based on fresh input data once they have been trained.

Deep Learning: It is a kind of machine learning that uses many-layered artificial neural networks (ANNs) to achieve impressive results in a variety of prediction tasks, including EDM. Deep learning architectures, such recurrent neural networks (RNNs) and convolutional neural networks (CNNs), can capture complex connections in both spatial and sequential data, like student performance on tests and student interactions with learning materials. Because of these qualities, deep learning is especially well suited for intricate EDM prediction tasks.

Personalised Learning: ANNs can be used to create customised learning programmes that change based on the needs and preferences of each individual student. ANNs can produce tailored suggestions, adaptive learning paths, and focused interventions to improve student learning outcomes by examining each student's past data and learning habits. This tailored strategy raises student motivation and engagement while enhancing the efficacy of education delivery.

Process of EDM

This section discusses transforming educational knowledge-related data through data processing and analysis. Figure 1 depicts the generalised EDM process, which includes data preparation, data mining, and result interpretation. Fundamentally, the procedure entails gleaning knowledge from educational data and applying it to enhance the learning environment (Acharya *et al*, 2019).

Preparing Education-Related Data: The acquisition of datasets is the most critical step; integration, selection, and pre-processing of data are typically included in preparing educational data. Structured (in the form of tables), unstructured (video or audio), and semi-structured (a combination of structured and unstructured) forms of education-related data are stored online. The data gathered may include important information that is erroneous or lacking, so pre-processing, normalisation, dimensionality, and data reduction transformation are required to attain the target data. Therefore, data preparation is the most essential phase of work follow-up.

Educational Data Mining: EDM uses data mining-related technologies to improve online education by modelling Big Data in Education and observing the correlation between learning academic outcomes and tutoring strategies. Utilised techniques include association rule mining, regression, prediction, and clustering (Mihaescu and Popescu, 2021; Zhang and Qin, 2018).

Interpretation of Result: The outcome summary analyses the results, the data's significant pattern, and its visualisation. The visual result displays the data's attributes to aid instructors in comprehending the data's qualities and making accurate teaching decisions regarding students' accuracy, study time, etc. The findings summarised online teaching strategies, student learning outcomes, and techniques to enhance tutoring strategies.

Challenges in EDM

Finding specific research gaps in Educational Data Mining (EDM) relies on the research work done up to 2022; additional discoveries may have happened since then. Some of the research gap are as follow.

Integration and Interoperability: It can be difficult to integrate many educational data sources, including learning management systems, student information systems, and external datasets. Creating standardised frameworks, protocols and formats could be the main goal of research to improve data interoperability between various educational platforms.

Dynamic Learning Environment: Research addressing the difficulties presented by dynamic and changing learning environments is needed, as online and mixed learning environments become more common. The crucial task is to gather the relevant EDM data in real time for the evolving landscape of educational platforms.

Longitudinal Analysis: Long-term studies examining the impact of EDM interventions over an extended period are relatively limited. To comprehend long-term repercussions on student performance and success, research might examine the effects of early intervention techniques, personalised learning approaches, and other EDM uses.

Teacher Involvement and Professional Development: Although data-driven decision-making (EDM) frequently concentrates on student outcomes, there is a research vacuum concerning the incorporation of instructors into this process. An important topic of research is how to enable teachers to interpret and implement EDM discoveries in the classroom.

Objectives of EDM

Academic and Administrative are the two major objectives of EDM. These two objectives have been described below.

Academic Objective: This objective has been divided into three major categories: entity-oriented, area-oriented, and institution-oriented (Sukhija *et al*, 2015).

* *Entity Oriented:* The major goal of this objective is individual-oriented, such as behaviour analysis, performance prediction, analysis of performance, and risk. This has been extended to both online and offline learning environments.
* *Institute Oriented:* This objective is related to organisation and development. The data are collected from the institutions, and the information or a meaningful pattern is retrieved.
* *Domain Oriented:* It is related to a certain branch or domain, and this purpose has unique methodological requirements in its approach. Decision-based system design is an example.

Administrative Objective: This objective is related to the management of the resources and the vision of the institution (Sukhija *et al*, 2015).

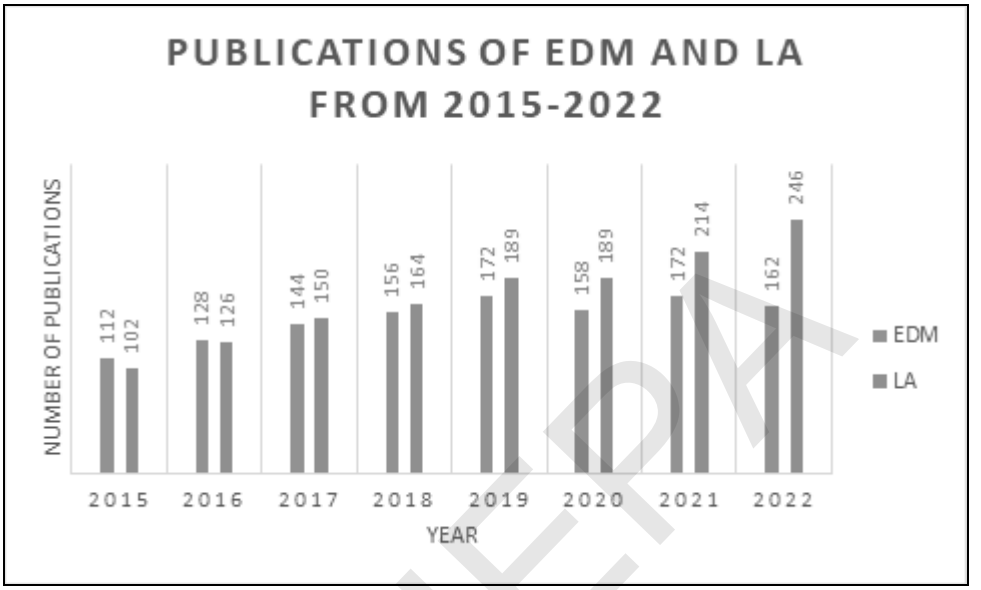
* Administrator Oriented: The major objective is infrastructure and utilisation of human resources, organisation, and academic relations.
* Inculcating multidisciplinary research practices with expert system tools.

Related Work

Data mining in education permits the analysis and extraction of data pertinent to education to construct models. These reproductions are models for adaptive curriculum recommendation, student performance prediction, etc. From 2015 to 2022, the growth of EDM and LA is depicted in Figure 2.

FIGURE 2

Publication of LA and EDM from 2015 to 2022



Based on the technology used and the data types and association rules, regression and prediction, classification, clustering, and diagnostic issues to be resolved, data mining techniques in education are frequently categorised into five categories. This field's research has been evaluated as follows.

It has been found that higher education institutions have consistently laboured to provide students with an excellent education. Using educational data mining (EDM), academic institutions can gain insight into student data and extract data for forecasting. The most devastating epidemic in recorded human history is COVID-19. All educational systems were compelled to adopt online learning (OL) due to the global pandemic. This study's dataset was derived from a survey conducted primarily during the COVID-19 academic year from the perspective of Pakistan's university students. The output of the trained model was then evaluated. SVM has outperformed all other techniques, generating the highest accuracy of any model tested (87.5 per cent). Then, using NB, KNN, SVM, decision trees, and logical regression during the COVID-19 era, an effective hybrid ensemble model of machine learning was used to predict student performance, producing outclass results; the hybrid ensemble model achieved 98.6 per cent (Asad *et al*, 2023).

Preprocessing, feature extraction, and classification are steps in predicting pupil achievement, as determined by Kaur and Gupta. Combining voting classifiers and principal component analysis (PCA), a novel model is constructed in this study for predicting student performance. Combining the Gaussian Naive Bayes, Random Forest, k-NN, and SVM classifiers yields the voting classifier. This study's methodology enhances prediction

accuracy, yielding an improved accuracy of 98.95 per cent and precision-recall and f-score values of 99 per cent (Kaur and Gupta, 2022).

Zhang and Qin (2018) online education as an online learning platform that stores vast quantities of behavioural and educational data on students. The researchers presented the fundamental notion of Big data in education (BDE). Then, the EDM procedure and the DM technologies and algorithms used in EDM are discussed.

Shafiq *et al* (2022) reviewed on the predictive methods used in Learning Analytics (LA), such as statistical analysis, Machine Learning (ML), and deep learning. The researchers have analysed several scholarly articles to illustrate their perspectives on resolving the issues with student retention in education. Statistics indicate that the overall college dropout rate is quite high, at 40 per cent, with 30 per cent of first-year students departing before their second year. It would be possible to combat this issue by creating early warning systems. The authors used the PRISMA model to search for and catalogue the articles used in this review. The authors concluded that the majority of researchers employed the ML-based algorithm.

Yagci (2022) proposed a model utilising ML techniques to predict the final exam results of undergraduate students based on their midterm exam results. This study's dataset consists of a sample of 1854 and has four characteristics: midterm results, final exam results, and faculty and department characteristics. ML techniques such as Random Forest (RF), Neural Network (NN), K- Nearest Neighbour (k-NN), Support Vector Machine (SVM), Logical Regression (LR), and Naive Bayes (NB) have been applied to the proposed model. The results conclude that the RF, NN, and SVM obtained the highest accuracy, whereas k-NN has the lowest. The classification accuracy of the proposed model ranges from 70 to 75 per cent.

Rahman and Islam (2017) proposed an EDM Framework to Support Unsupervised Programming Learning. Beginning with problem-solving, data collection, and pre-processing, the devised framework followed this order. Then, the MK-means clustering algorithm was employed to place relevant data in the same clusters. The Euclidian distance concept was used in this method. The Frequent Pattern (FP) growth algorithm was used to extract data patterns and association rules, and the latter was proposed based on extracted pattern suggestions. The dataset contains 70,000 real-world problems solved by 537 programming students (DSA) (Data Structure and Algorithm). The outcome demonstrates that the model developed in this study effectively extracts valuable patterns, characteristics, and rules from problem-solving data.

(Ragab *et al* (2021) built a model using an Ensemble Classifier to forecast student performance based on classification methods from Data Mining (DM). The datasets for this investigation were derived from two distinct sources. 480 student instances and 16 attributes are present in the first dataset (DS1) from Kaggle. The UCI Machine Learning Repository provided the second dataset (DS2). Boosting techniques such as Random Forest (RF) and voting classifiers have been applied. For better results, various classifiers were gathered, such as Naive Bayes (NB), Support Vector System (SVM), k- Nearest Neighbour (k-NN), Artificial Neural Network (ANN), Decision Tree (DT), and RF using vote procedure. The result demonstrates that bagging increased the performance of models with DT where accuracy with DT upgraded from 90.4 per cent to 91.4 per cent and increased in Recall and Precision from 0.904 to 0.914 and 0.905 to 0.915 respectively.

Prada *et al* (2020) developed a web-based software application that analyses the pupil performance based on their scores. This dataset is obtained from the learning management

system using only the variables derived from the administrative data of the students. The k-means clustering technique was implemented, and then the data were visualised to a low dimension for Principal Component Analysis (PCA). Support Vector Machine (SVM) was used to classify students into Excellent, Average, and Low-Performance classes. Logistic Regression was used to predict whether a student will complete the course or drop out. The accuracy ranges from 85 to 91 per cent.

As it is a challenging Science, Technology, Engineering, and Mathematics (STEM) task, Lien *et al* (2020) predicted student plans of action. The purpose of the study was to close this gap by evaluating the accuracy of predictions made by 43 elementary school teachers while attempting to solve ill-defined problems (IDPs) in which the solution is not explicitly specified. The light path task was considered one of the ill-defined problems in this study. In addition, the machine prediction algorithm was applied to the problem, and it was determined that the accuracy of expert predictions is considerably lower than that of machine prediction techniques.

Bonifro *et al* (2011) discussed the issue of student attrition, which is the most complex and detrimental for students and educational institutions. To address this issue, a tool based on Machine Learning techniques has been devised to predict the first-year graduate student dropout rate. On the dataset, Linear Discriminant Analysis (LDA), SVM, and RF were implemented. In addition, their specificity was calculated. The authors concluded that RF will perform well with implementing ALR (Additional Learning Requirement).

Dewantoro and Ardisa (2020) proposed a solution to the problem: predicting an undergraduate student based on the study duration and Grade Point Average (GPA). The dataset was extracted from the Electronics and Computer Engineering faculty's admissions system between 2010 and 2014; the main variables considered in this study include High School (HS) origin, HS main, HS Grade, GPA, and length of study. ANN, k-NN, and NB were the three primary techniques applied to the dataset. ANN performed the best with 92.143 accuracy for GPA prediction and 87.857 accuracy for the duration of study prediction.

Hutagaol and Suharjito (2019) created the most accurate model for predicting student attrition. As many as 17432 samples were collected from the private universities in Jakarta. The model was constructed using ensemble classifiers consisting of k-NN, NB, and DT. The performance of individual classifiers 64.29 (NB), 64.84 (DT), and 75.27 (k-NN) improves by approximately 79.12 per cent when combined with Ensemble Classifier Methods, and Gradient Boosting is used as a meta-classifier. Using 10-fold cross-validation, the highest accuracy achieved was 98.82 per cent.

Moscoso-Zea *et al* (2019) reviewed the EDM methods and algorithms so that education-related data analysis could be conducted and decision-making could be enhanced. According to the analysis done in this study, Random Trees had superior precision but suffered from a disadvantage because of difficult interpretation. In contrast, the J48 algorithm can better interpret outcomes for classification visualisation and result interpretation.

Using the clustering method, Febriana *et al* (2019) discussed a group of pupils from Makassar City Public High School. Admitting the students to the school produces a lot of data related to the student, which impacts searching unique patterns from a massive volume of data. The ML clustering technique k-Means was used to classify the students; k-Means is a non-hierarchical clustering technique used to cluster data based on similar data types. The data used comprises information on 22 schools and 1,547 students in total.

The objective of this study is to distribute the data evenly among the institutions to avoid duplication, and as a result, 22 clusters have been formed. Moreover, 1547 students' information has been distributed evenly among institutions.

Impact of Student Behavioural Features on Student Learning Performance

This subsection discusses the impact of pupil learning behaviour on their performance. Student performance is influenced by behavioural characteristics such as assessment submission, attendance, raised hands, viewing announcements sections, academic performance, and doubt clearance sessions. Rahman and others discussed the impact of students' absences and behavioural characteristics on their academic performance. This study employed NB, ANN, DT, and k-NN as classification methods. The ensemble approach contains Bagging, ada boosting, and RF used to increase the model's accuracy. The results indicate that ensemble filtering obtained high accuracy, 84.3 per cent, whereas ada boosting on ANN achieves only 78.6 per cent accuracy (Rahman and Islam, 2017).

Amrieh *et al* (2016) proposed a student prediction model based on data mining and learner behaviour. The student's performance has been predicted using ANN, NB, and DT classifiers. In addition to this ensemble technique, the combination of Bagging, Boosting, and Random Forest has been implemented. It has been determined that there is a strong correlation between the learner's behaviour and academic achievement. The accuracy of the proposed model has been improved by 22.1 per cent, and in most instances, the accuracy obtained exceeds 80 per cent.

Liang *et al* (2016) discussed the dropout prediction of learners in massive open online courses (MOOCs) in which the main predictor is the student's learning behaviour (monthly log data) to predict that the student will drop out within the next ten days. The data for 39 courses was obtained from the EDX open-source platform. The most significant feature is the student's behaviour log, extracted from the dataset alongside metadata such as student course enrolment ID. The classification was performed using Logistic Regression (LR), Support Vector Machine (SVM), Random Forest (RF), and Gradient Boost Decision Tree (GBDT) after feature extraction using Logistic Regression (LR). Researchers have determined that GBDT increases accuracy by 88 per cent.

Using the Experience API web service (X-API), (Amrieh *et al*, 2015) obtained a dataset from the e-learning platform Kalboard 360 to develop a novel learner performance model with behavioural attributes. Utilising DM techniques such as ANN, NB, and DT classifiers, the influence of behaviour features on students' learning behaviour has been analysed. As a consequence of removing the behavioural features from the dataset, the classification accuracy improved by 29 per cent.

TABLE 1

Summarised Literature Review

Year	*Approach*	*Result*
2023 (Asad *et al*, 2023)	The hybrid Ensemble model was developed using Machine Learning techniques like Decision Tree and Logistic Regression.	Accuracy 98.6 per cent
2022 (Kaur and Gupta, 2022)	Proposed model is the combination of Principal Component Analysis (PCA) and Voting classifier.	Accuracy 98.95 per cent, Precision, Recall and F-Score 99 per cent
2022 (Romero and Ventura, 2022)	Pre-processing was applied to the collected data then MK means clustering has been applied, and further FP growth was applied to extract the pattern from the data.	Developed model efficiently extracting the pattern, features and rules from problem solving data.
2022 (Yagci 2022)	The model has been developed based on the ML technique; RF, NN, k-NN, NB, SVM, and LR classifiers were applied.	RF, NN, SVM achieved the highest accuracy and k-NN achieved the lowest accuracy range 70-75 per cent.
2021 (Ragab *et al*, 2021)	Using the voting procedure various classifiers combined together (NB, k-NN, SVM, DT, AND RF)	The Bagging technique with DT increases the accuracy (91.4 per cent), and recall and precision values obtained were 91.4 and 91.5 respectively.
2020 (Prada *et al*, 2020)	To cluster the k-means clustering technique was applied and PCA was applied to visualise the data in lower dimensions at lastly SVM was applied for the classification.	The SPEET tool was developed and accuracy ranges 85-91 per cent.
2020 (Lien *et al*, 2020)	Machine Prediction Algorithm was proposed for all ill-defined problems.	The expert system has significantly lower accuracy than the machine prediction system. The updated Mean of precision and Mean Reciprocal are 45.6 per cent and 0.597.
2020 (Dewantoro and Ardisa, 2020)	ANN, K-NN and NB techniques have been applied to the dataset.	ANN performs best among all the techniques. The accuracy achieved by ANN is 92.143 per cent.
2020 (Del Bonifro *et al*, 2020)	Linear Discriminant Analysis was applied to reduce the dimensionality of the dataset, and then SVM and Random Forest were applied to the dataset	The tool has been developed based on ML techniques that will predict the dropout rate of first-year students. With the introduction of the feature ALR, Random Forest Technique has performed well.

Contd…

2019 (Huta-goal and Suhar-jito, 2019)	The Ensemble classifier uses Gradient Boosting.	The accuracy attained was 98.82 per cent with 10 cross-validation.
2019 (Moscoso Zea *et al,* 2019)	Random Tree, NB, and J48 algorithms applied.	The research suggests that random trees had better precision but had disadvantages due to complex interpretation, whereas J48 algorithm had a better possibility of interpretations of results in visualisation of the classification and interpretation of results.
2019 (Febri ana *et al,* 2019)	For school zoning K-Means clustering technique was used in which Euclidian Distance was used to determine the distance of school points and the address of students concerning school points.	22 clusters were formed in which the 1547 students' data has been evenly distributed.
2017 (Amrieh *et al, 2017*)	The ensemble method has been applied, which includes Bagging, Boosting, and Random Forest.	There is a strong relationship between learner behaviour and academic results. The accuracy of the proposed model has been increased by 22.1 per cent by including the behavioural features.
2017 (Rahman and Islam, 2017)	NB, ANN, DT, and k-NN were used as classification techniques. Ada boosting and RF were also used to increase the accuracy of the model.	The result indicates that the ensemble filtering technique had achieved fine accuracy, i.e., 84.3 per cent.
2016 (Liang *et al, 2016*)	Learning Behaviour log data of the student was taken for dropout prediction in the next days. LR, SVM, RF and GBDT.	GBDT has increased accuracy with 88 per cent.
2015 (Amrieh *et al, 2015*)	Artificial Neural Network, Naive Bayes, and Decision Tree	The results reveal a major relation between learner behaviour and academic results. By using behaviour features, there is a 29 per cent increase in accuracy.

Techniques That are being Employed to Facilitate EDM

To better understand and enhance learning and educational processes, educational data mining (EDM) applies data mining techniques to educational data. The following are some methods that are frequently used in EDM and result in prediction.

Learning Analytics: In order to comprehend student learning behaviours and results, learning analytics entails gathering, evaluating, and interpreting data from educational platforms and systems. Future academic outcomes can be predicted and significant insights into the learning trajectories of students can be gained from techniques including measuring engagement metrics, evaluating performance on assignments and examinations, and tracking student interactions with learning materials.

Data Preprocessing: Preprocessing methods are used to clean up and format unprocessed educational data so that they may be analysed. This could include normalising the data, encoding category variables, resolving missing values, and eliminating outliers. Preprocessing data effectively guarantees that it is prepared for activities involving analysis and prediction.

Feature Engineering: Choosing or developing informative features from the instructional data that can be utilised to forecast student results is known as feature engineering. Features could include socioeconomic circumstances, learning materials used, involvement with learning materials, demographic data, and past academic success. The goal of feature engineering is to identify pertinent facets of student performance and behaviour that affect learning outcomes. (Priya R. M. *et al*, 2020).

Predictive Modelling: Building models that can forecast student behaviour or outcomes based on past data is done through the use of predictive modelling approaches. For prediction problems in EDM, supervised learning methods like regression and classification are frequently utilised. These models employ trends that they have identified from historical student data to forecast future performance on standardised tests, academic success, and dropout risk.

Ensemble Learning: Multiple predictive models are combined using ensemble learning approaches to increase prediction resilience and accuracy. EDM can be used with ensemble techniques like bagging, boosting, and stacking to combine several information sources and capture intricate correlations in the data. Ensemble approaches are very helpful for handling imprecise or noisy educational data (Dong *et al*, 2020)

Temporal Analysis: Analysing student behaviour and performance across time is known as temporal analysis. When analysing educational data, time-series analysis approaches can be used to spot seasonality, trends, and temporal patterns in students' learning behaviours. Through the use of historical data and temporal analysis, instructors may forecast future performance and monitor the growth of their students over time.

Evaluation and Validation: Predictive models in EDM are evaluated using approaches for validation and assessment. This could entail dividing the data into training and testing sets, computing accuracy, precision, recall, and F1-score, as well as cross-validation. Thorough assessment guarantees that forecast models are dependable and capable of being applied to fresh data.

By utilising these methods, educational data mining may make use of the abundance of educational data at its disposal to forecast student performance, pinpoint kids who are at-risk, tailor instruction, and assist in educational decision-making.

Discussion

This paper presents a systematic review of educational data mining (EDM), also known as the extraction of educational data. EDM and LA are two interdisciplinary fields where EDM places a strong emphasis on the study and creation of automated and data-driven techniques for discovering patterns in massive volumes of educational data, and LA focuses on collecting, analysing, and extracting the knowledge from learning-related data for understanding and enhancing learning. During the review, it was determined that the data classification methods implemented were NB, SVM, ANN, and k-NN.

Figure 3 presents the trend of frequently used LA keywords over the five years in the LA article (Lemay *et al*, 2021). In general, the trend indicates that highly specialised terms such as "predictive analytics," "machine learning," and "deep learning" have supplanted more general terms such as "learning assessment" and "student learning" as the most frequently used EDM keywords on LA. This indicates that EDM practitioners and academics in Los Angeles are increasingly interested in utilising EDM to develop and implement innovative approaches for enhancing LA practices. Figure 4 shows the trend of frequently used LA keywords in the EDM article over five years.

FIGURE 3

Trend of Frequently Used LA Keywords over the Five Years in the LA Article

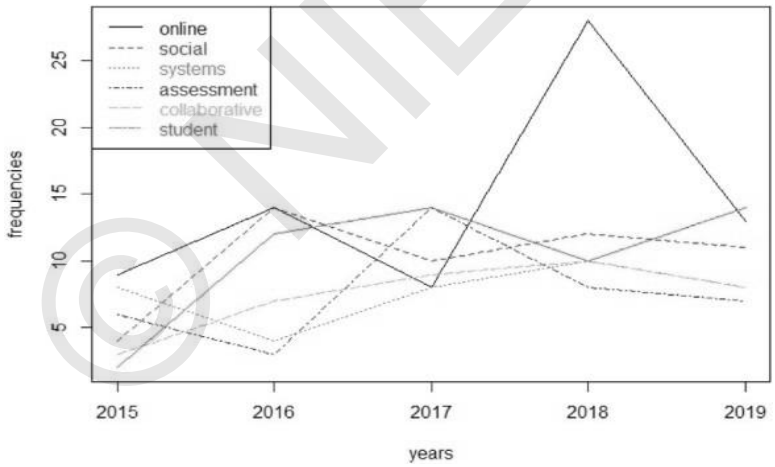


FIGURE 4

Trend of Frequently Used LA Keywords in the EDM Article over Five Years

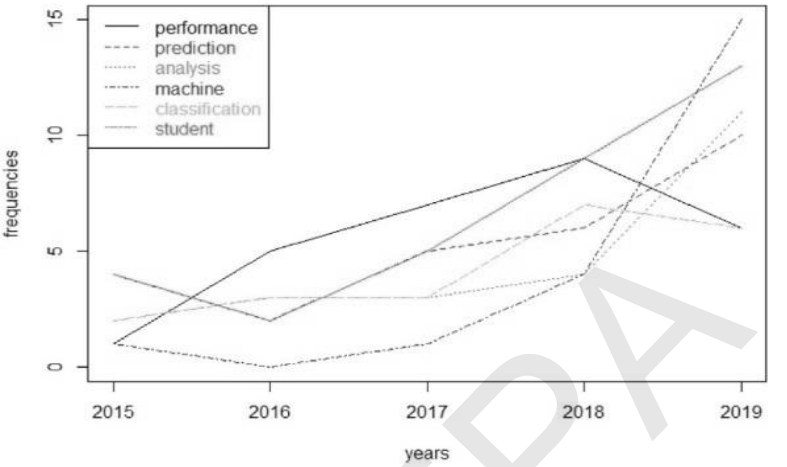


Figure 5 represents the trend of frequently used EDM keywords in the LA article over the five years. Figure 6 presents the trend of frequently used EDM keywords in the LA article over the five years.

This research seeks to provide scholars and instructors with a deeper understanding of how EDM can be utilised in education and how to implement EDM strategies to improve educational quality. The development of extensive data has created numerous opportunities for online education; the emergence of new mining applied science will provide improved techniques and competencies for applying EDM in online education.

FIGURE 5

Trend of Frequently Used EDM Keyword in the LA Article over the Five Years

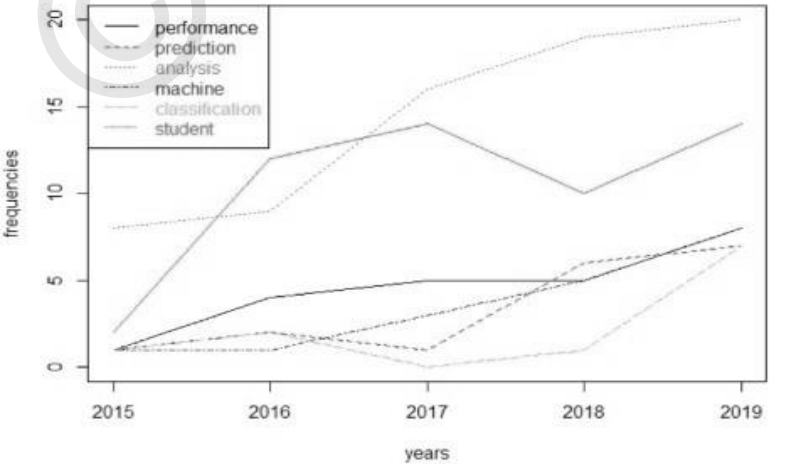
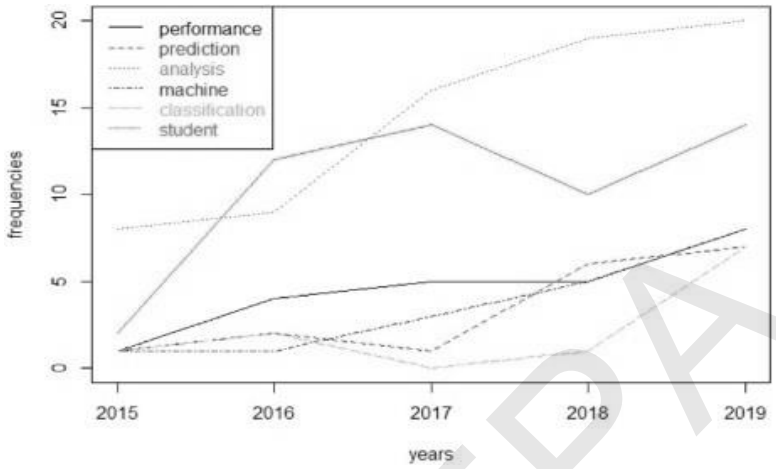


FIGURE 6

Trend of Frequently Used EDM keyword in the LA Article over the Five Years



In addition, the recent emergence of new EDM keywords such as "causal inference" and "recommendation systems" indicates that the LA field continues to develop and expand. As EDM researchers and practitioners construct new and more sophisticated EDM methods, we can anticipate even more innovative and consequential EDM applications in Los Angeles in the near future. New approaches will also result in more valuable knowledge, a more scientific evaluation process, and an improved future for online education. Nonetheless, care must be taken to resolve administrative, moral, and technical obstacles and academic statistic mining restrictions, all designed to enhance the search for educational information mining in online education. Students in an educational setting or through looking into things like feedback, assessment, and outcomes are the main focus of EDM and LA. Both sectors must investigate the outcomes and contributions of students and instructors in various domains. In addition, the recent emergence of new EDM keywords such as "causal inference" and "recommendation systems" indicates that the LA field continues to develop and expand. As EDM researchers and practitioners construct new and more sophisticated EDM methods, we can anticipate even more innovative and consequential EDM applications in Los Angeles in the near future. New approaches will also result in more valuable knowledge, a more scientific evaluation process, and an improved future for online education. Nonetheless, care must be taken to resolve administrative, moral, and technical obstacles and academic statistic mining restrictions, all designed to enhance the search for educational information mining in online education. Students in an educational setting or through looking into things like feedback, assessment, and outcomes are the main focus of EDM and LA. Both sectors must investigate the outcomes and contributions of students and instructors in various domains.

Conclusion

From 2015 to 2022, the current state of EDM is examined in this paper. The impact of student learning behaviour on their results and the significant factors affecting learning have been discussed briefly. EDM has been a significant research field relevant to numerous well-established research fields, including traditional data mining, association, clustering, classification, regression, and forecasting. This study discusses the process of educational data mining, which is the cycle of gaining knowledge about education-related data and trends of frequently used keywords such as EDM and LA over five years. The academic and administrative objectives of EDM have been discussed. The primary future directions for EDM are related to using larger datasets for a deeper comprehension of data. In addition, the dataset's dimensionality is increased for a greater comprehension of each attribute. For a clear comprehension of the educational system, it is necessary to acquire a precise data set, which is not currently available. In a previous investigation, it was determined that datasets lack both dimensionality and size. In the context of current methodologies, it has been observed that there is a need to use the hybridisation-based method, improve the credibility of EDM, and compare other methods based on performance parameters such as accuracy, precision, recall, and f-score. EDM is a dynamic discipline where research is continuously conducted to solve new difficulties, develop new models, and improve methods. The long-term viability of EDM applications depends on ongoing development and the incorporation of the most recent scientific discoveries. The field of educational data mining (EDM) in machine learning has enormous potential to change many facets of education in the future. Students' learning experiences can be made more individualised with the use of machine learning algorithms on educational data. Through the evaluation of learning styles, preferences, and performance, these algorithms are able to suggest customised learning materials, flexible learning schedules, and one-on-one tutoring to meet the specific requirements of every student.

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Managing Education amid Covid-19 Pandemic: Handling Online Teaching in Delhi Government Schools

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Introduction

The education sector has been hit hard by the Covid-19 pandemic, which has affected many students worldwide. According to the UNESCO data, about one billion learners have been affected worldwide due to this virus. Data (accessed on July 5, 2020) on UNESCO's official website reveal that of the affected learners, at least 320 million were from India. School closures have been common non-pharmaceutical interventions used during an epidemic or a pandemic (Cauchemez et al, 2009: 473). For example, the outbreak of the influenza pandemic in 1918, the Asian Flu pandemic of 1957, and the Swine origin of influenza H1N1 in the year 2009 led to school closures in order to prevent a spread of the virus. School closures could be proactive and reactive. The school is closed under proactive school closure before any virus transmission from one student to another happens. In contrast, reactive closure is the closure of schools when staff members or children experience illness. India adopted the strategy of proactive closure after the Covid cases in the country started to increase.

The schools in India were closed in the middle of March 2020 after the country was put in a state of complete lockdown. It was to break the chain of the spread of the corona virus. The proactive closure of schools worked well in containing the spread of a disease, as could be seen from an example of school closure in the US during the influenza pandemic spread in 1919. It was observed that the states that adopted the proactive closure strategy had lower death rates than the states that adopted the reactive closure strategy in the country (Markel et al, 2007: 644). School closure can lessen the burden on the country's healthcare system

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and help in giving time to build the required infrastructure. Nevertheless, schools' closure could also be devastating for some students because it is more than learning institutions.

Situation in Delhi

Schools are not only the learning centres for a child but also an entity where he gets physical, mental, social, and emotional support. During school closures, the most vulnerable population is students from low-income families, the disabled, and students whose families have lost their jobs. Many disadvantaged students depend on the free meal they get at the school. India's mid-day meal scheme is one of the largest globally, in which the country serves around 100 million children in a year (IFPRI, 2020). Therefore, the students could be impacted by school closure by affecting the availability of basic food and increasing diet diversity among school children. Around 9.12 crore Indian students do not have mid-day meals due to school closure (*The Wire*, June 2020). Students also receive counselling related to studies, carrier, and mental and physical well-being. Most of the government schools in India provide free sanitary napkins to girls. Girls from classes 6 to 12 in Delhi Government schools receive free sanitary napkins under the Kishori Yojna Scheme. Similarly, they are also given counselling on menstruation hygiene in their schools. The school closure also meant that the access to sanitary pads for schoolgirls became difficult, and they had to compromise on the score menstruation hygiene.

School closures also had an economic cost. Many families lost their job as a result of this pandemic. There was increased absenteeism of parents from their jobs because they had to take care of their children staying at home after school closure. According to a UK study, 16 per cent of the workforce would be absent from their jobs if the schools are closed, as they have to be at home to look after their children during the school closure (Cauchemez: 2009: 7). Absenteeism from work would further impact the nation's economy, and the absent parents would face pay cuts. In India, the people who belonged to the low-income strata suffered the most. Many left their workplace and migrated to their native places after losing their jobs. As they left along with their children, they could not support their children's studies. According to the Centre for Monitoring Indian Economy, the urban unemployment rate in India was 11 per cent as of July 12, 2020. There is also an apprehension that many of the students dropped out of school as their parents were now unemployed. Many of these students were involved in child labour in order to support their families.

School is also a social space where students have positive and fruitful interactions with their peers, teachers and other school staff members. It could also be a place where a student can relax and forget the day-to-day struggle which (s)he faces due to the financial, health, or other personal issues at home. Teachers provide him with a safe space to forget his problems (Doucet, 2000: 9). The closure of schools may therefore create anxiety and stress in students. They could also face abuse or violence at home. Some might also face problems like physical abuse or violence in the absence of a safer space at home. A report says that the Child Helpline number in India received 92,000 calls by the eleventh day of the countrywide lockdown. Most of these complaints were against abuse and violence (*The Hindu*, April 2020). The increased complaints show that schools can provide a safe space for children to escape from abuse or violence outside school.

Social isolation from friends, teachers, neighbours, etc., could lead to mental stress and anxiety. With a lack of interaction and counselling services provided by the school, children

with mental stress could take extreme steps. There have been initiatives by the Delhi Government for school students to cope with stress during the school closure by providing helpline numbers. However, the effectiveness of Tele counselling is still not known.

A teacher plays a vital role as (s)he knows the students and can better analyse the social, emotional and mental perspective of a student. Teachers can connect to their students only through online mode or telephonically during school closure.

After the declaration of school closures, there was an immediate need to address the problem of access to education for millions of students who were bounded to stay home in the wake of the nationwide lockdown in India. As a result, most schools moved to online teaching in order to connect with the students. However, the school administration and teachers faced several challenges, such as lack of digital infrastructure, dropping out of students due to out-migration with family, coping with students' stress during the lockdown, etc. The country's low-funded private schools and government schools faced these problems most as the children coming to these schools usually belong to low-income families.

The Delhi Government schools similarly faced challenges after their closure in the middle of March 2020. They then adopted some short-term strategies to deal with the problem of school closure.

Objective and Methodology

The objective of the study is to highlight the problems that the education sector has faced due to COVID -19 pandemic and what could be the way forward. It will mainly look into the efforts that have been put by the teachers and administration of Delhi government schools of Zone 23 and 24 of district.

The survey was initiated by constructing an online survey using Google form. A voluntary response sampling method was used and a questionnaire was prepared with 29 questions related to online teaching. A total of 2119 teachers from Zone 23 and 24 of district South, Delhi Government schools, participated in the survey. The participants responded on the basis of their experience from April 2020 to July 2020.

Teachers of the Delhi Government school in Zone 23 and 24 of the South district were the targeted population who responded to the questionnaire. Various subject teachers participated in the survey, such as English, physical education, EVCG, music, etc. There were 30 subject teachers who responded to the questionnaire. Most of the teachers who participated in the survey fell between the age group 31 to 40, i.e., 38.8 per cent of the total.

Due to the non-availability of a standard questionnaire on this topic, the research team opted for a self-made questionnaire. It comprised 29 questions in both Hindi and English languages; these were of three question types: Multiple Choice, Checkbox, and Short Answer. The Multiple Choice type had only one answer to choose from among the options given to the teachers. In the Checkbox type questions, participants had the choice to tick on more than one choice. A parallel method has been used to check the validity of responses. To limit the space in the paper, only 11 questions have been compiled and analysed, and the remaining questions were to be used for administrative purposes for future references.

The survey aimed to find out what measures the teachers and administration of Zone 23 and 24 of Delhi Government schools adopted measures to teach students online during this pandemic. The study can be used as a blueprint for online education during a man-made or natural disaster in the days to come.

Analysis and Findings

Immediate Steps Taken by the Directorate of Education (DoE), Delhi: Initially, the DoE directed schools to suspend morning assembly and biometric attendance of staff. It ordered to close the schools for primary classes. Later the closure of schools for all classes and staff was announced. The task now was to move to online teaching. The DoE came up with a pilot project named 'Project Aspiration' for a technology-driven learning environment for students. In April, the DoE started its collaboration with a private coaching institute, viz, 'Carrier Launcher,' targeting and helping Class XII students in phase one.

Additionally, the department introduced the online Maths classes for class IX students in the state, in collaboration with another private coaching institute named Khan Academy (*India Today*, 2020). There was also an introduction to the department's online spoken English language and personality development programme. In collaboration, British Council and McMillan Education initiated this programme for classes X and XII students who were waiting for their final results to be declared. The classes went on in May and June 2020 (*Hindustan Times*, May 2, 2020).

Besides, the department also started sending links to the daily activities to the students of Nursery to Class VIII via SMS and through WhatsApp groups. Another significant programme launched by the department was the online Happiness classes for students. It was resumed online in April, where students from Classes I to VIII started doing activities such as storytelling and meditation at home for 45 minutes daily. These initiatives by DoE were the need of the hour. They helped students who were left confused and anxious about their studies due to the lockdown. Teachers' and parents' roles have been crucial in the successful commencement of online classes. Factors like motivation and enthusiasm were found necessary to keep the teachers religiously involved in their assigned tasks.

Initially, there were no direct orders from the DoE to conduct online classes. The private schools in the state started taking online classes for the students, but there was no such provision in the Delhi Government schools. Leaders of these schools then decided what should be the way forward for students who were waiting for their studies to resume. It was a crucial time primarily for the students in the transitional classes, i.e., students of Classes X and XII. The online classes started in Zone 23 and 24 of Delhi Government school provide an example of the teacher-led initiative to keep students' morale high during this challenging time. They became a crucial part of communication with their students and helped them become part of the online classes initiated by them.

Steps Taken by School Administration and Teachers of Zone 23 and 24 after School Closure: There are 72 government schools in Zone 23 and 24, of which 41 are in Zone 23 and 31 are in Zone 24. These include Sarvodaya schools, Rashtriya Pratibha Vikas schools, and School of Excellence. Total enrolled students in the session 2019-20 were 99,690, while 1,08,481 students attended the session 2020-21.

The primary source of connecting with students in these schools was WhatsApp, as most of the government school students' families own a smartphone. However, the availability of devices like laptops, a tab, etc., in these families is meagre. There was a top-down approach in connecting the education administration to the principals of schools. The teachers then further connected themselves to students and parents in both the zones through WhatsApp groups.

These WhatsApp groups were meant for all the subjects taught in these schools. Various subject coordinators also joined the teachers of Zone 23 and 24 through these WhatsApp groups. The administration initially reached out to all the school heads through Zoom meetings and guided them about the ways forward.

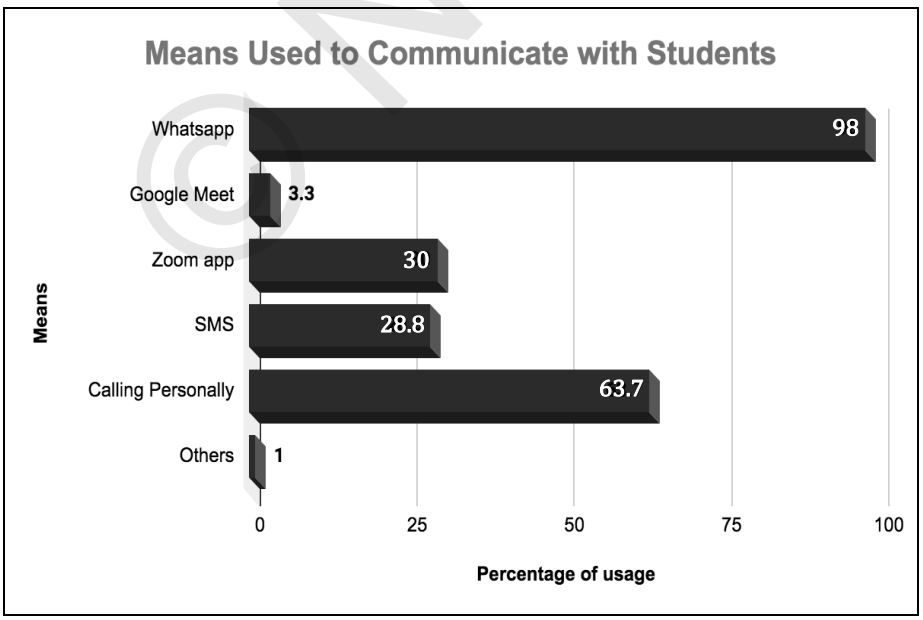
The administration of Zone 23 and 24 connected itself to the teachers by forming a number of subject groups. It also held Zoom meetings with each subject group and briefed the teachers about how to handle the situation. It becomes essential to give liberty to teachers in the decision-making process in such conditions, as they know their students and problems better than any other person around them.

Eventually, teachers commenced online classes in both zones under the administration's guidance. The teachers participated and tried to cover the curriculum and engage the students by using the Zoom app, WhatsApp, Google classroom, Microsoft Team, etc. The teachers of the subjects like physical education, home science and music also conducted online classes. The following survey analyses the view of the teachers of both zones on online education. It highlights some of the positive and negative sides of online teaching in government schools. Teachers have also given suggestions on what they think can be done to improve the current condition of online education in Delhi government schools.

Means to Communicate: The question related to the means of communication was of checkbox type, so teachers opted for more than one option. Teachers mainly used the WhatsApp platform to connect with students online. About 98 per cent of teachers said they use WhatsApp, giving students calls to connect with them. Some 63.7 per cent said that they call students personally to connect with them.

FIGURE 1

Means to Communicate with Students



Teachers also mentioned the use of other means such as the Telegram app, voice messages, Webex app, etc.

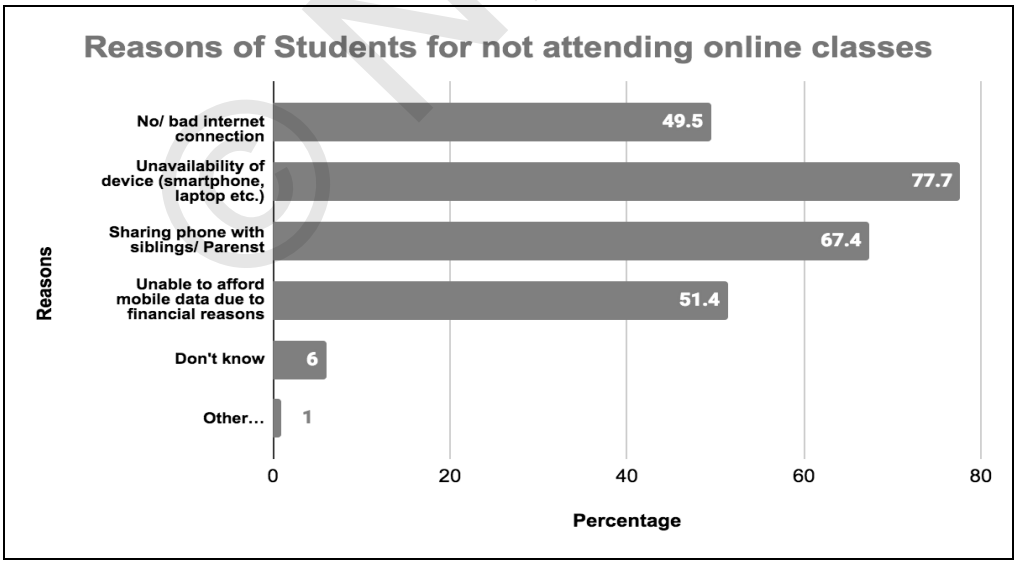
Students' Participation Rate: Students' participation rate is crucial for the successful conduct of online classes. As many as 33.8 per cent of the teachers reported that the students' participation has been between 61 to 80 per cent. About the same percentage rate of teachers reported the participation rate of 41 to 60 per cent of students. Many teachers also reported that initially the participation rate of students was reasonable, but it started to decline after some days.

Reasons for not Attending Online Classes: This was a checkbox type question with more than one option. Teachers have mentioned many reasons for students not attending online classes. The primary reason which 77.7 per cent of teachers mentioned is the unavailability of devices such as laptops, tabs, etc. Since most of the students in Delhi Government schools belong to low-income families, the availability of these devices is significantly less. Even if these devices are there in the family, they have to share them with their siblings. The second reason teachers (67.4 per cent) mentioned for students not attending online classes was the sharing of the phone with siblings/parents. Lack of mobile data and lousy Internet connection were other reasons mentioned by the teachers.

Other significant reasons highlighted by teachers for students not attending online classes were that some students are unwell and some had gone to their homes with their families. Some students were not enthusiastic about their online classes because the annual result was not declared yet. At the same time, online classes have already started.

FIGURE 2

Reasons of Students for not Attending Online Classes



Teaching Methodologies Used: On asking about the new methods teachers have introduced for online teaching, they mentioned using the zoom app, WhatsApp, self-made notes, and PPTs to reach students. Many teachers said that they prepare videos for students and demonstrate activities by making video calls to the students, such as making a video of science experiments through a video call. Many parents were concerned about the security issues related to the use of the Zoom app; therefore, teachers' self-made videos were beneficial for students.

Similarly, many teachers have used NCERT channels, e-pathshala, and apps like BYJU, Carrier Launcher, Khan Academy, Diksha, etc., to teach students. Online teaching has especially been interesting for subjects like physical education and home science. Most of the physical education teachers said they made their videos of daily exercises and Yoga exercises available to students and asked them to send pictures back to teachers of students doing Yoga.

Many teachers have tried to include the topic of Covid-19 in their teaching methodologies to make them aware of the problem. For example, a music teacher said she makes poems and songs related to the Covid-19 problem and sends them to students. An English teacher said she has made and shared a puzzle related to Covid-19. A sociology teacher said that she gave students lessons about the importance of family during such an uncertain time and how students could make their family bonding secure in this lockdown. A home science teacher said that she teaches about the herbs that students can grow at home and use them to increase immunity to fight against corona. She also asks students to send pictures of their activities at home.

Almost all of the teachers said they had told their students that they could contact their teachers if they faced any problems at any time of the day. They have made them available all-day round for the students.

Level of Satisfaction with Online Classes: As many as 50.5 per cent of teachers said students were satisfied with online classes. Teachers who opted for the 'maybe' option were 31.8 per cent, followed by 11.3 per cent 'not satisfied', while 2.5 per cent said some are satisfied and some are not. Teachers mentioned that students are more comfortable with offline classes. Many students cannot afford the necessary mobile data and/or do not have devices for online classes.

Preference for Online/Offline Teaching: Most teachers, 65.8 per cent, opted for a combination of both online and offline teaching. These teachers believe that the online option is better for providing notes and assignments to students. It also offers better virtual teaching aids for a better understanding of concepts. However, they opined that offline teaching is better for students' better participation and discipline in the class. Teachers opted for offline teaching were 30 per cent of the total, and only 3.6 per cent of teachers preferred online teaching.

Advantages of Online Classes: This was again a checkbox type question with more than one option. Teachers who preferred online classes opted for various options for online classes' advantages. Around 51 per cent of teachers said that students are more interested in online teaching because it is a new experience. Some 38.4 per cent of teachers also said that the online teaching methodology is an activity that generates more interest among students. Also, 36.4 per cent of teachers opined that students could chat personally with their teachers and fellow students through online mode. They also opined that online mode allows

students to connect any time with the teachers without any time limitations. May teachers said that this is the best option to use in the time of a pandemic.

A primary class teacher said that it was difficult for minor-age children to follow social distancing measures and maintain hygiene by themselves; school opening will only increase their problems. Additionally, teachers mentioned that online teaching promotes inclusiveness and gives good exposure to students to technology. The advantage highlighted most by teachers was the opening up of students who have been introverts in the class. They said that such students started asking questions during online classes and participated enthusiastically in the class.

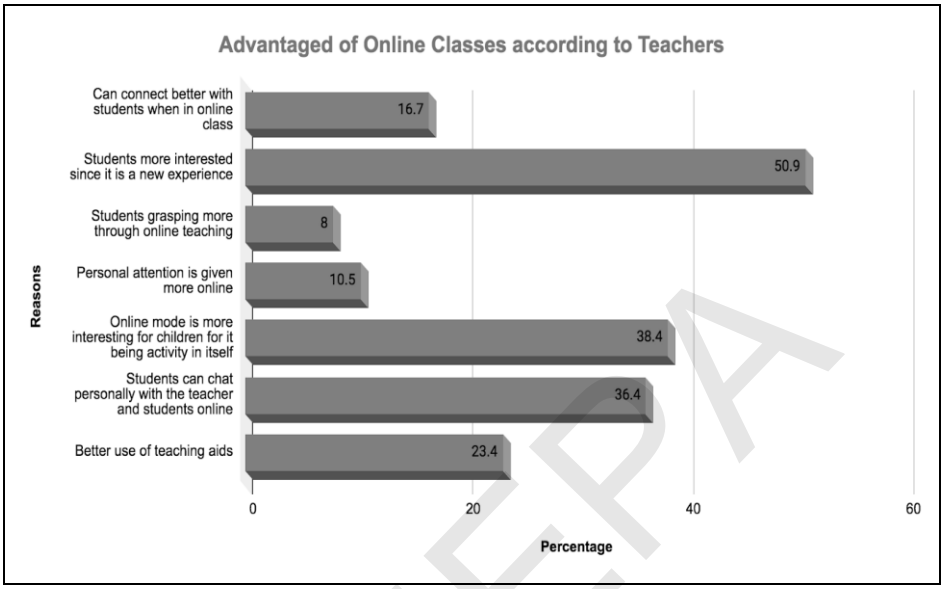
Advantages of Offline Classes: Due to the sudden shift from offline to online classes, teachers found it difficult to contact every student. There has also been dissatisfaction among teachers on many levels with online classes. About 79 per cent of teachers mentioned that offline classes give a better scope of personal attention and students' monitoring. Teachers also feel that offline teaching provides better participation of students in the class. About 68 per cent of teachers think they can better identify students who do not pay attention when teaching in a physical classroom. Similarly, 50 and 60 per cent of teachers opined that offline teaching maintains better discipline and allows eye contact with students, respectively.

Additionally, teachers said that students' evaluation or assessment is more efficient in offline classes. The classes become more interactive with good attendance. They also mentioned that many students do not get the environment required to study at home, and school is the only place where they get the opportunity for overall development. Furthermore, according to them, this option is also more economical and inclusive. For subjects like physical education, a physical classroom is ideal. While favouring offline classes, teachers raised many other points against online teaching based on the problems they have faced while teaching students online. Some of the issues raised were:

- There is no time limit set for taking online classes, which results in longer screen time.
- Delhi Government has divided the students from Class 6 to 8 into three groups based on students' learning ability. These are Pratibha, Nishtha, and Neo Nishtha. The Pratibha group mainly consists of students who are good at reading, writing and basic mathematical skills. Students of Nishtha are at the learning stage of these skills, while Neo Nishtha group students are lowest in performance at these skills. Online teaching mode is not fruitful for Nishtha and Neo Nishtha group students as they are still at the learning stage of reading and writing.
- Students of families with a low income cannot afford the cost of online classes.
- Students have become lethargic and lazy towards their work, and teachers spoon-feed study material to them.
- Monitoring and assessment of students are complex for subjects like Maths.
- Students using their parents' phones had to wait until night for their parents to return from work; it was only then that they could submit assignments. As a result, many of them also miss online classes.

FIGURE 3

Advantages of Online Classes according to Teachers



Despite being critical of online teaching, teachers agree that they are now learning to use technology, which is a pleasant experience. It is mainly instrumental for teachers in sharing study material among students. This platform has also allowed one to analyse the teaching methodologies. Teachers now prepare themselves in advance with teaching aids for the classes. Some of them agreed that online mode has helped them connect better with parents too, and they are working in tandem with them to support online classes for their wards.

Teachers have also tried to listen to students' problems through phone calls. Some teachers send motivational voice messages to their promising students. One teacher has pointed out that he calls his students randomly and asks them about their health and progress in the subject. Another Science teacher says that he has kept one day of the week as 'Celebrating Fun Day,' where he sends and shares jokes, poems, a biography of famous personalities, etc. Teachers, therefore, have played an essential role in giving emotional support to students during this lockdown.

Parents and Students' Response to Online Classes: On the basis of the feedback taken by teachers from parents and students, it was found parents have supported online teaching initiatives. Teachers were informed that parents are finding this as the safest way to provide education to their wards during this pandemic. Parents have provided their phones and helped their wards with their assignments and worksheets wherever needed. They feel that their child does not have to lose on studies during the school closure. In many cases, parents are in regular touch with the teacher regarding their ward's studies and other issues related to their children. However, parents who cannot afford mobile data or phone for their wards when they are off to work are facing problems.

Teachers also said that some parents are not very happy and gave negative feedback for online classes. Majority of them are concerned about the increasing screen time of their wards and related health issues with that. They are also concerned about the security issues related to internet usage. They do not want their child to misuse the given internet facilities under the shield of attending online classes.

On the other hand, most of the students are very happy with online classes. They are optimistic about the online classes as they get a hand on experience with technology. They are excited to learn new methodologies being used by teachers through technology. Their exposure to this type of teaching mode is recent, and they like it.

However, they do miss their physical classrooms when it comes to completing assignments and getting emotional support. Students have said that their classmates are very helpful when they face any difficulty studying. Many parents do not have enough education to assist their wards in their studies. Especially the students of lower primary and upper primary classes need the support of someone to do their assignments and worksheets. Some students have also pointed out to their teachers that there are many concepts that they do not clearly understand in online classes.

The online classes system is new to students and teachers; basic arrangements for online classes are necessary. Students and teachers would have been more comfortable if they had previous experience in taking and conducting online classes. On asking teachers whether they require any seminar or training to teach online classes, most of them (77.7 per cent) favoured it.

Teachers were happy that they were connected through subject WhatsApp groups of their respective subjects and could share their problems, lesson plans, teaching material, etc., with colleagues. Zoom meetings were held for each subject taught in Zones 23 and 24. These Zoom meetings held in DDE's presence aimed at knowing the well-being of teachers, charting methodologies to teach their subjects online, and discussing problems that teachers are facing during online classes. Almost all the teachers favoured regularly holding such meetings with DDE to manage the online classes better.

Suggestions Given by Teachers

There are some common points on online teaching on which teachers agree. These are as follows:

- **Support disadvantaged students:** Many students cannot afford the Internet data for these classes. Some of the students do not even have a smartphone. Many children share phones with their parents; they have to wait for their parents to return home from work; only then they can submit their work. It is, therefore, crucial to provide devices for such students to attend online classes. Cash incentives can be given to these students to buy data for attending online classes.
- **Low attendance needs to be checked:** There are many reasons for the low attendance of students. Many students have migrated to their hometown with their parents and cannot attend these classes. Students in transitional classes are not motivated for these classes since their results are still awaited due to the school closures. Since there are no set-out rules for these classes and attendance is not

mandatory, students are not taking these classes seriously. Some rules need to be made to regularise the attendance; a proper timetable could help.

- **Cyber security issues:** Students' unrestricted and unsupervised Internet usage in the shield of online classes could be harmful to children. Teachers believe that we need to teach students netiquette to avoid cyberbullying or other risks of misusing the Internet. Initially, all the teachers used the zoom app to take online classes, but later due to security issues, the government issued a warning about the app's usage. Online teaching is a new field for both students and teachers. Therefore, there is a scope of errors on both parts. Teachers are also concerned about their privacy. The safety issues related to using the Zoom app have made them cautious about the security risk associated with using technology. India's Ministry of Home Affairs issued an advisory in April 2020 on using the Zoom app and said that it is "not safe" to use. It was noted that specific steps need to be taken to ensure safety. Some teachers are not comfortable getting calls and buzzing WhatsApp messages from students, even during the odd hours.
- **The need for guidelines on online teaching:** Teachers also found a lack of fixed timings for conducting online classes. As a result, the screen time of both students and teachers has increased. Being available all the time on various apps has created stress on teachers. The well-being of teachers in this process is equally important. Proper guidelines for online teachings, such as a well-thought timetable, attendance requirements, Internet ethics, etc., are needed.
- Some teachers have suggested that there should be a separate website for uploading all the study material, assignments, class lectures, etc. It will reduce the continuous pressure to use smartphones on teachers and students. They will be able to access it anytime they want. Teachers have also suggested TV programs for video lectures so that the students who do not have digital devices can access study material, and the inclusivity is maintained.
- **Combination of online and offline teaching:** Teachers have agreed that online and offline teachings have their benefits. They opine that online teaching should continue to be part of teaching methodologies even when the COVID-19 crisis is over. Some subjects like science, physical education, and home science need practical classes for which the physical classrooms are required. The special education teachers and Educational & Vocational Guidance Counsellors (EVCG) cannot solely depend on online teaching. Students of the lower primary, upper primary and those of the 'Nishtha Group' especially need the physical presence of teachers and assistance while using technology.
- **Training of teachers to conduct online classes:** Many teachers do not have hands-on experience of using technology. There is also a scope of learning ethics related to online classes. Teachers are still at the learning stage. Most teachers feel that a seminar or training to conduct online classes could be helpful for the smooth functioning of these classes.

Considering these suggestions by teachers, it is evident that teachers are optimistic about online classes but expect to have proper infrastructure for conducting these classes. They are also concerned about the disadvantaged students deprived of these classes if not

supported financially by the government. Formal training and a regular timetable with set guidelines could make these classes more inclusive and prosperous soon.

Discussion

There is much scope for improving the infrastructure needed for online education in Delhi and other parts of the country. According to Statista (an online portal for data), the Internet penetration rate in India was 50 per cent in the year 2020. This means that only half of the country's population had an access to the Internet. The online portal for statistics further pointed out that the Internet's highest penetration rate was i.e., 69 per cent in Delhi, in the year 2019. The active mobile Internet users stood at 629 million in 2020. There are also variations in access to the Internet according to gender, income, and region. When it comes to access to online education, there are many barriers that students and teachers face, some of which are as follows.

Digital Divide: A visible digital divide preset in the Indian online education system harms the disadvantaged and vulnerable population. A sizeable number of students will not access these online classes due to various reasons. This vulnerable population is mainly students who belong to low-income families, students who out migrated with their parents, students whose parents have lost their jobs, and other such students who are left excluded due to this pandemic.

According to the NSS data from the 75th round (July 2017 to June 2018), the percentage of persons aged five years and above who can operate a computer and have the ability to use the Internet was 16.6 and 20.1 per cent, respectively in India. In which, Delhi's percentage of persons (above age 5) having the ability to operate computers was 42.8 per cent, and the ability to use the Internet was 50.5 per cent. The proportion of households having a computer was 34.9 per cent in Delhi. Students in Delhi government schools have accessibility to a smartphone through which they attend online classes. Very few have other devices such as computers, laptops, tabs, etc., to access the Internet. It is comparatively difficult to use smartphones for online classes and doing assignments for students. They are entirely dependent on WhatsApp for daily assignments and worksheets. According to teachers in the survey, it is quite stressful for the eyes, about which many parents complained. There is still a long way to go to provide a set infrastructure to Delhi government schools for online education.

Even if students manage to attend online classes on the phone, the availability of only one device in the house is another problem that they have to phase. Data plans and widgets are also costly for them to buy. Therefore, the solution to minimise this digital divide is needed soon to have inclusiveness in the Delhi government schools' online education system.

No Size Fits All: Teachers have highlighted that different subjects have different methodologies and requirements to teach. Online education has certain limitations in subjects like physical education, home science, science, other practical subjects, vocational subjects, etc. The physical presence is necessary for these subjects. There is a need to take different measures for students with special educational needs and disabilities. Students who are slow learners or weak at using technology need special attention and assistance.

Need for teachers' prior training: Most of the teachers in these schools are new to online teaching, and many are also new to operating computers or other technical devices. The teachers have felt the need to have training before online classes. Proper guidelines, timetables, netiquettes, etc. would help them. Teachers are dependent on the trial-and-error method for taking online classes. There have been cases of online bullying of teachers during online classes. 'Helicopter parenting' has further put pressure and created a disturbance for teachers. Therefore, ethical and netiquettes training is required for both teachers and students. Many teachers are not well equipped to take online classes. They mostly take online classes with smartphones as they do not own a personal laptop or computer at home. Accessing assignments, worksheets, official circulars, etc., becomes stressful and cumbersome through mobile phones. A set infrastructure for online classes is the need of the hour for both students and teachers.

Increased screen time: The increased screen time of students has been one of the major complaints of parents noted by the teachers. They say that students have complained of headaches and stress on the eyes due to the overuse of screened devices. There is an urgent need to have a set timetable for online classes and assignments given to students through WhatsApp (most teachers use this app to provide assignments and worksheets to students). India's Ministry of Human Resource and Development (MHRD) has released guidelines "Pragyata: Guidelines for Digital Education" related to students' screen time. It has been recommended that pre-primary students' screen time should not be more than 30 minutes in a day. It is further recommended that it should be limited to two sessions of 30 to 45 minutes for classes 1 to 8 and four sessions for classes 9 to 12. The frustration of the overuse of digital screens is seen in students, parents, and teachers. Parents who have started going to work after the lockdown in Delhi receive teachers' messages when they are at work. Their ward can only access and complete the worksheets, assignments, etc. only, when their parents return home from work.

The problem of assessment: Despite all the teachers' efforts to give online classes to students, the lack of assessment tools is still a hurdle. Teachers have tried to make quizzes through Google form and ask students questions during online classes, but the effectiveness of these efforts is still questionable. Students' strength in most of the classes is more than 40, so the assessment becomes difficult. A practical solution or tool for assessment is necessary for the justified use of online classes.

If we overcome these obstacles related to online classes, then only we can have an inclusive and effective learning process for students. There is a need to address gaps present in the Indian online education system to provide education to every student of the country. As an ancient African proverb says, "It takes a village to raise a child." It will thus be the responsibility of teachers, parents, and the community to educate the country's children in this challenging time inclusively.

Maslow before Bloom to fill the gaps from start: Many students are dependent on schools for their everyday meals in India. The mid-day meal scheme introduced by the government was quite successful in drawing students to school and increasing the enrollment ratio. The school closures have hit this scheme hard; however, MHRD advised all the states to provide mid-day meals or food allowances during this pandemic. In March, some cash incentives were given to Delhi Government school students, but students did not receive these allowances in April, May, and June (Hindustan Times, July 2020). It becomes crucial for

schools to continue providing food to students for their overall development. The objective of providing online education to students will be futile if students cannot meet the basic demands of having food.

As for the current situation, a famous phrase in education says: “Maslow before Bloom.” Bryan Pearlman too has used this phrase in his book *Maslow Before Bloom: Basic Human Needs before Academics*. The phrase has become ever more critical in the field during the Covid-19 pandemic. The phrase is related to the theories of two American psychologists, Abraham Maslow and Benjamin Bloom, respectively. Abraham Maslow gave the theory of "Hierarchy of Needs," and Benjamin Bloom developed the pyramidal model of "Bloom Taxonomy". We often come across Bloom's taxonomy when we are in the field of education. Bloom's taxonomy's main objective was to classify the thinking behavior that could help in learning. It consisted of three domains: Cognitive, affective, and psychomotor. The model consists of a classification of learning according to the six cognitive levels of complexity (Forehand, 2005: 2). The various levels of cognitive learning skills from lower to higher levels were: knowledge, comprehension, application, analysis, synthesis, and evaluation (Mullen: 2020). Teachers, curriculum makers, etc., have used the various levels in education to encourage students to set goals to reach from lower-level to higher-level learning.

On the other hand, Maslow’s hierarchy consists of five tiers of human needs. These are physiological, safety, belonging, esteem, and self-actualisation. He considered physiological and security needs as the basic needs of humans. He pointed out that if a man is missing everything in life, his motivation would be physiological needs over every other need. Once this need is satisfied, he can think about other necessities of life. He gave an example that if a man does not have food, safety, love, and esteem, he would prefer food over any other need (Maslow, 1943). If we talk about this in the context of education, we see that if parents cannot provide basic needs to their children, they will not be motivated to go to the upper level of the hierarchy of needs. If they can provide basic needs to their children, they can focus on the following two levels of hierarchy, i.e., belonging and esteem at school (Mullen, 2020). The last stage of self-actualisation is related to the constant struggle to develop professionally and personally. A man can only achieve it after he has passed through all other stages of the hierarchy. As Maslow has said, "What a man can be, a man must be" (Maslow, 1943: 382).

When we apply these two theories in the current pandemic scenario, many people have been left unemployed. Parents of many students in the Delhi Government schools are daily wage workers, semi-permanent, or employed in the informal sector. Joblessness has made it difficult for them to provide food for their families. Earlier, many students who have been getting their daily meals from schools have not been getting them now because of school closures. Until and unless their basic need for food is not met, they will not be motivated to learn or get an education.

Therefore, the main objective for teachers, parents, and the community now should be “Maslow before Bloom.” Then we can further aim to achieve various levels of Bloom's Taxonomy for learning once students' basic needs have been fulfilled.

After students' basic needs are fulfilled, we can think about the modes through which the learning process can be started for the students. The online classes are ideal for the current situation. However, due to various hurdles related to this teaching method, we need to have a blended learning model for teaching students that include both synchronous and asynchronous ways of learning.

Recommendations

Path of Blended Learning to be Followed: The UNESCO has advised countries to adopt high tech, low tech quickly, and no tech approaches to provide education during this pandemic. Problems such as the digital divide, low attendance, and lack of assessments are present when it comes to online education. Blended learning is one such approach that can help in overcoming these issues. Blended learning is a methodology that integrates both computer-based online teaching and face-to-face teaching. It could be an excellent solution for Delhi Government schools where the partial infrastructure for technology is present; we can fill the learning approach gap. Bonk and Graham have thus defined Blended Learning:

"BL is the combination of instruction from two historically separate models of teaching and learning: traditional face-to-face learning systems and distributed learning systems. It also emphasizes the central role of computer-based technologies in blended learning." (Bonk & Graham, 2005: 5)

The government needs to invest in this idea of blended learning. Students will have time, pace, and place flexibility while learning under this teaching method. Teachers will also have the opportunity to have an inclusive and stress-free approach to teaching. Within blended learning comes personalised learning, where students who are faced with the challenge of the digital divide can adjust their learning process according to their background, need, interest, and passion. It needs to be student-centric, authentic, flexible, and competency-based (Travino, 2017). In other words, personalised learning is done on the basis of the needs of students.

Keeping Check on Stakeholders of Education: It is essential to take care and keep a regular check on all the education stakeholders during this pandemic. As discussed earlier, students' mental, physiological, social, and emotional stress needs to be checked to provide a safe learning environment for them during this pandemic. Apart from students, parents are also worried about the accessibility of education for their children. Many have been left unemployed and facing economic hardship. It becomes vital for schools to provide a daily meal to the community to overcome these hardships. Delhi Government schoolteachers have supplied and distributed food rations to the people of the area they serve during this pandemic.

However, we should not forget that teachers also face many problems in changing the working environment, health risks due to pandemics, mental stress, etc. We need to consider teachers' needs, without which the learning environment will be disrupted. It will take a community to handle and overcome the hurdles created by this pandemic for the teaching-learning environment.

Conclusion

School closures could have negative and long-term impacts on the lives of students. It provides the platform for students' physical, mental, and emotional support. The school closures have disturbed the regular and smooth functioning of students' learning environments worldwide. India has hastily moved from offline teaching to online teaching after the school closures. This has led many teachers to re-work on their technical skills to provide online learning to students. The Delhi Government school teachers are examples of

voluntary efforts to fill the gaps created by school closures. Most of their students are from disadvantaged backgrounds, and online education accessibility has been a big hurdle. Providing inclusive education is one of the challenges in front of these teachers. They also feel that they need to be trained for better working of these online classes. They have played the role of educators and someone who has provided emotional and mental support to their students. They have also been at the forefront in providing various services, such as the distribution of rations to needy people, working at the quarantine centers made by the government, compiling government data needed for handling corona cases, etc.

It has been evident from the survey that teachers want this digital divide to be removed soon and suggested various measures for the same. They have indicated that students should be provided smartphones, mobile data, phone recharge packs, a single website to upload and access study material, etc. Most of the teachers have felt that online education solely cannot fulfill the purpose of providing education to students and opted for a combination of both online and offline classes. Blended learning, therefore, could be the next thing in the education system of India. The students' curriculum needs to be reframed by including creative, flexible, and student-oriented characteristics. The new National Curriculum Framework needs to inculcate more ICT-based features in it. The Government of India has promoted various digital education platforms and TV and Radio channels to continue students' learning process. Some of the government's online learning resources are DIKSHA, e-Pathshala, National Repository of Open Educational Resources (NROER), Swayam, Swayam Prabha, Nishtha, and National Digital Library, etc. However, the need of the hour is that the government provides proper infrastructure and guidelines to make online teaching successful in the country. As also suggested by UNESCO, we have to adopt the high tech, low tech, and no tech solutions for the country according to the area's needs. All the education stakeholders need to buckle up for the new changes in teaching pedagogy. We must be inclusive while implementing the online classes system during this pandemic and when the schools are open. Many students would have dropped out of school; probably, some would have lost their loved ones; some would be anxious and stressed. We need to be supportive and provide every care required by these students. Bloom will never happen if we do not consider Maslow's needs for students, parents, and teachers.

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RESEARCH NOTES/COMMUNICATIONS/COMMENTARY

Attitude of Pre-Service Teacher Educators of India towards Education for Sustainable Development: The Contexts of Gender, Institution Type, Teaching Experience and Regional Background

P. K. Sahoo*

Introduction

Education plays a vital role in achieving the sustainable development goals (SDGs) encompassing the environmental, social and economic components of present and future life. Education for Sustainable Development (ESD) is an emerging multidisciplinary concept that integrates the approach of sustainability in achieving the goals of SD. It generates knowledge, attitude and skills to establish a more sustainable and fair society with global orientation. As per UNESCO (2014), ESD is holistic and transformative in nature. It is integrated with learning content, pedagogy and learning environment promoting sustainable competencies of life. The core competencies cover critical and systematic thinking, collaborative decision making and taking responsibility for future generation. Encouraging teaching learning in this direction requires teachers' capability building exercises on continuous basis. Lifelong learning and continuous professional development of teachers is an essential input for promoting ESD based pedagogies in the school system. Teacher development practices must be integrated with autonomous learning strategies to achieve the goals of ESD. Hence, the role of teacher educators is considered as a valuable ingredient of building sustainable development competencies among pre-service teachers as well as in-service teachers. In this regard the National Education Policy (NEP, 2020) envisages the development of teachers to "ensure that every teacher has the flexibility to optimise their own development, as teachers." Developmental opportunities "will be available to all teachers so that each teacher may choose what is most useful for their own development." (NEP, 2020). Teacher educators must be made competent enough to deal with such commitment in the context of sustainable development. Their attitude towards ESD is also considered as a significant indicator of their prominent role in such direction. Since attitude formation is a matter of contextual interventions of pluralistic factors like gender, institution

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type, teaching experience and regional disparities in the Indian subcontinent, this is significant to explore the effect of such variables on teacher educators' attitude towards ESD. The study on pre-service teacher educators will be of great use in transforming the teacher education curriculum for development of competent teacher educators for ESD.

A review of literature revealed that there had been efforts to explore the attitude of teachers (in-service and pre-service) towards sustainable development. Very little has been mentioned in research on education for sustainable development (ESD). Moreover, the preparedness of teachers and teacher educators about promotion of ESD through teacher education programmes has not been explored through researches in India and abroad. So far, no study has been conducted on attitude of teacher educators towards ESD in the context of prominent background factors. On this rationale, the present study aimed at exploring the level of attitude of pre-service teacher educators (PSTEs) towards ESD and studying the effect of background factors like gender, institution type, teaching experience, and region on attitude towards ESD in the Indian context.

Hypotheses of the Study

The hypotheses were stated in the null form.

- There is no significant difference between mean attitude scores on ESD of women and men pre-service teacher educators.
- There is no significant difference of mean attitude scores on ESD between pre-service teacher educators enrolled in university teaching departments and colleges of education.
- There is no significant difference between mean attitude scores on ESD of pre-service teacher educators with teaching experience and without teaching experience.
- There is no significant difference between mean attitude scores on ESD of pre-service teacher educators belonging to different regions of India

Operational Definition of Attitude towards ESD

This is defined as the learned tendency or readiness of teacher educators to react to the key features of education and research for sustainable development as measured by the teacher educators attitude scale on ESD.

Methods and Procedures

The researcher constructed and validated the attitude scale on ESD consisting of twenty items in three points Likert scale form. The content validity was ascertained through opinion of experts. The Alpha Cronbach value for all the 20 items included in the final scale was found to be 0.714. It indicates a high reliability accepted index of above 0.60. The test-retest reliability coefficient of the tool was found as 0.94.

Population and Sample

The study was conducted at the all-India level covering the population of all the pre-service teacher educators, i.e., post graduate education students enrolled in university teaching departments and teacher education colleges rated by NAAC with minimum B+ rank. In all, 14 institutions offering PG education programmes were chosen randomly from the list of NCTE and NAAC approved teacher education institutions in India, such as, East (3), North (4), West (3) and South (4) respectively. In all 600 pre-service teacher educators from North (200), East (180), West (120) and South (100) zones consisted of the sample of the study.

Data Collection, Scoring and Analysis Procedure

Data were collected through administration of tool among the respondents from sample institutions. Data scoring was done by assigning three marks to positive response, two marks to uncertain response and one mark to negative response on attitude scale Data were analysed by employing descriptive statistics, t-test and ANOVA to test the null hypothesis of the study.

Major Findings of the Study

The descriptive analysis of data revealed that, as a whole, the sample respondents had expressed positive attitude towards ESD with mean value of 45.29, i.e., above 40 midpoint of the attitude scale This indicated just above average level of attitude of the respondents. The statistical techniques applied to test different null hypothesis revealed significant difference between mean attitude scores on the basis of gender and region. Hence, the hypotheses of no difference of mean attitude scores were rejected at .01 level with regard to such background variables. There was no significant difference between mean attitude scores on the basis of institutions type and teaching experiences. The t value of mean difference of attitude scores indicated that women pre service teacher educators had higher level attitude towards ESD than that of their men counterparts. The ANOVA findings revealed significant effect of region on attitude. The post test results revealed the supremacy of East and North region sample respondents over South and East region pre service teacher Educators. Therefore, the result indicated significant effect of gender and regional background on attitude of PSTEs towards ESD.

Discussion on the Findings of the Study

This is a first kind of study at national level to explore the attitude of pre-service teacher educators towards ESD. The findings of above average level of attitude of the respondents is an indicator of their inclination towards teacher education for sustainable development cutting across their institutional background and teaching experience. However, the variation existing with regard to background of gender and region highlight heterogeneous nature of attitude towards ESD of pre-service teacher educators. Several studies conducted in India and abroad on teachers' attitude towards sustainable development confirm the overall findings of the present study. Studies conducted abroad by the researchers

on preparatory teacher education programmes have expressed positive attitude of teacher trainees towards ESD. Ertepinean *et al* (2012) and Redman (2013) revealed positive findings on development of sustainable competencies among students. On teachers attitudes towards sustainable development, studies conducted by Haris (2010), Burmeister and Eliks (2013), Hanifah (2015) and Borges (2019) found positive attitudes of teachers towards sustainable development. In the Indian context studies conducted by Dash *et al* (2008), Ravikiran (2008), and Sahoo (2022) highlighted the findings about teacher respondents' positive perception about ESD. Some such studies revealed effect of age, socio economic status and training exposure of teachers on their attitude towards ESD.

Implications of the Findings of the Study on Teacher Educators' Education

There is an urgency to reshape teacher educators' education in view of development of competencies of sustainable development among pre service teacher educators. This is a positive indication that the pre service teacher educators of the country have expressed positive attitude in this regard. In this context, special curricular provisions should be available for further enhancement of their attitude and competencies concerning ESD. With a view to minimise regional discrepancies on their attitude, this will be worthwhile to promote flexible learning opportunities on ESD as an integral part of postgraduate programme in education. Moreover, alternative provisions be available for professional development of teacher educators in different areas of sustainable development,

Conclusion

The study's findings have contributed to bringing reforms in teacher educators' education in terms of development of knowledge and attitude in the area of ESD. The pre-service teacher educators' appreciation of ESD at the all-India level gives a positive direction to prepare the teacher educators for introduction of sustainable teacher education programmes at different grades. The study is the first of its kind of research on teacher educators' education on ESD. Appropriate educational programmes focusing on sustainable competencies need to be developed for empowerment of teacher educators on SDGs with special reference to India.

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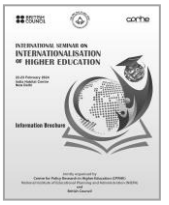

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Book Reviews

TILAK, Jandhyala B. G. (2024): ***Economics of Engineering Education in India: Growing Challenges of Expansion, Excellence and Equity***, Routledge, pp. 364, ISBN: 978-1-032-38572-3, Price: ₹ 1595.00 (Hard Bound)

Engineering education forms the backbone of higher education globally and in India. There is a macro policy environment within which the growth and expansion of engineering education has taken place. There are several other critical issues like imbalances in the growth of different branches of engineering education, quality of education, gender inequality and other inequalities by caste, region and economic status and labour market conditions affecting the demand side of engineering education. There is also the broader issue of provision and growth of the private sector vis a vis the public sector in the supply side of engineering education. Thus the book addresses the growth of engineering and technology education, while noting the unevenness in regional provision, and examines the status and prospects of the field. The book discusses how the private sector has grown much faster than the public, thus widening the inequalities in access to different socioeconomic groups and thereby exacerbating the concerns relating to declining quality. What is new and interesting in this book is a novel treatment of problems facing India for a long time and the impact of engineering education on economic growth and development.

This is a very timely book considering the focus on higher education overall in the National Education Policy 2020 and more specifically, selected issues in engineering education. The author, Jandhyala B. G. Tilak, is an established and outstanding expert of higher education. Here he weaves together the disciplines of economics and higher education, and puts across the related evidences. In the Indian context this book, well empirically rooted, is one of the few of its kind on engineering education issues. Thus the book uniquely positions itself to combine economics and engineering education in a novel manner to address the topical issue of growth of engineering education and its wider impact on the economy.

Chapter 1 gives the "Introduction and Context," synthesises and gives a preview of what to expect from the book. The chapter discusses in detail how investment in technical education makes a vital contribution to economic growth in terms of higher rates of growth of the economy's productivity. This is particularly crucial to the development of developing countries. Higher technical education, specifically engineering education, is one of the most important components of human capital. This, in fact, is seen as 'specialised human capital.' The returns to such specialised human capital are estimated to be very high.

Based on a study of the Indian Council of Social Science Research, the book is structurally divided into two parts. While Part I chapters are based on the secondary databases, Part II chapters are based on primary data collected as part of a wider study

jointly by Stanford University and National University of Educational Planning and Administration.

Chapter 2 titled "Engineering Education in India: Challenges of Growth and Inequalities" is well researched and gives a macro picture of engineering education in India, the current status, trends over time, and inequalities in engineering education by gender, caste, regions. All-India data and state-wise data, pertaining to the most recent years, are used for this purpose giving the most up-to-date picture on the current status of engineering education and how it went through different transitions during the last seven decades. It identifies the problems, and critically looks at some of the reforms that have been attempted and some of the major recommendations made by several committees, yet to be implemented for the improvement of engineering education in India.

Chapter 3 is on "Emergent Challenges of Engineering Education in India: Quality, Finances and Employment" and focuses on the concerns relating to the declining quality of engineering education, unstable public funding and labour market interface of engineering education. The quality concerns in engineering education starts with a discussion of the teachers' position, their recruitment and their qualifications, as these are significantly related to the quality of faculty which will have an impact on their teaching and research. The issues on regulation and accountability are also well analysed using National Board of Accreditation (NBA) reports and other policy documents of the AICTE (All India Council for Technical Education) and MHRD (Ministry of Human Resource Development) with an expectation that they may reveal relatively unknown factors This chapter also reviews some curriculum-related issues that are linked to the much debated industry-academia linkages.

Part II of the book examines in depth some of the phenomena observed at macro level using primary data. It consists of six chapters, each deliberating on a specific aspect. The questions examined are: students' choices of engineering colleges – public or private; students' choices of disciplines within engineering – modern subjects like electronics, computer engineering and IT related subjects of engineering vis-à-vis conventional subjects like mechanical, civil or electrical; the extent and determinants of household expenditure on engineering education; student loans as a method of funding engineering education; and quality of engineering education and external efficiency of engineering education – labour market effects, viz. employment and earnings of engineering graduates.

Chapter 4 is titled "Who goes to Private Engineering colleges and Why?". While presenting a socio-economic profile of engineering students in India, it examines the factors that explain who goes to private institutions. Even though a good number of private colleges of engineering are getting closed during the last few years and enrolments in private colleges are declining, private sector still accounts for a major share both — in the number of institutions and in student enrolments in technical education as well as in general higher education. This interesting phenomenon is well documented and analysed in the chapter.

Chapter 5, titled "Students' Choice of 'Modern' versus 'Traditional' Streams of Engineering Education," analyses the shift in demand in favour of such disciplines. Thus while branches like mechanical, civil and electrical engineering have enjoyed huge popularity for a long period, in recent years areas like computer science engineering, electronics and communication engineering, information technology (IT) and telecommunication engineering have gained more popularity. Some of these popular streams have been introduced in Indian institutes of engineering education only during the

last quarter century, coinciding with the revolution in information and communications technology.

Chapter 6 is titled "Family Expenditure on Engineering Education and Its Determinants." Here, an examination of household costs of engineering education is attempted, wherein it is noted that students spend heavy amounts on acquiring engineering education, both in public and private institutions. Student loans or educational loans have been an important source of financing of higher education. Introduced after restructuring in the early 1990s, educational loans have become popular, particularly for expensive professional and technical education. Loans are expected to help economically weaker sections of the society to improve their participation in higher education. But in practice, not only the poor but also the rich take educational loans. Thus Chapter 7 titled "Funding of Engineering Education: Scholarships, Other Financial Assistance and Education Loans" analyses who gets educational loans and what are the factors that determine the receipt of loans by the students. The large expansion of engineering education seemed to have happened at the expense of quality of education. While many research studies focussed on perspectives of the institutions, the policy makers, educational administrators, employers and policy makers, here the attempt in Chapter 8, titled "Students' Perceptions on Quality of Engineering Education," is to analyse students' perspectives on the quality of their education. In fact, many students were found to be content and satisfied with the quality of their institution. Chapter 9, titled "Employability, Employment and Earnings of Engineering Graduates," looks at the students' preferences and labour market conditions faced by graduate engineers in terms of employment and wages. A summary of the study, with a few major concluding observations and their policy implications, is given in Chapter 10 which makes up the concluding Part III of the book.

This book will be of immense value to students, teachers and researchers of education, higher education, engineering education, economics of education, sociology of education, and education and public policy. It will also be useful for policymakers and administrators in higher education, engineering/technical education in advanced as well as emerging economies.

This book is certainly an outstanding contribution to the under-researched field of engineering education in India and marks a significant way of using an economics lens to study engineering education, its value and importance over the years and its myriad manifestations. However, while reading the book, one feels there could have been an additional chapter or section on new and emerging technologies like Artificial Intelligence, Machine Learning, Robotics and their impact on engineering education and the labour market making it even more contemporary.

The book is an exceptional piece of work by Jandhyala B. G. Tilak and certainly cuts across disciplinary boundaries to tackle the macro and micro level issues in engineering education in a way never seen before and certainly exceeds all expectations of a book in this area of higher education research.

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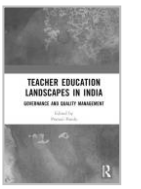

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