Education in the Era of COVID-19

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Abstract

This paper reports the findings of a descriptive survey research that explores higher secondary school students' experiences with Mathematics remote learning during the Corona Virus Disease-2019 (COVID-19) school closure in Odisha and analyses another similar-purpose research done in Zambia, in detail. Quantitative and qualitative data were merged to provide a comprehensive analysis of the main findings in the context of the existing literature, the government's response to COVID-19 school closure, and the challenges associated with remote learning during that time. Research findings show that being a peri-urban student hinders access to private tutors and coaching centres whereas even after having an access of nearly every possible resource, the urban students were lagging behind owing to heavy distraction and short attention span in the online mode. The report compares these finding to those observed in Zambia. In Odisha, a huge popularity of private e-learning platforms and YouTube was observed, in contrast to the miniscule level of interest in their Governmental counterparts. Open-ended questions are analysed by coding and thematization to support the statistical results. Based on these, some practical solutions are provided to tackle the issue in both Odisha and Zambia.

Introduction

In late December of 2019, first cases of an unusual type of viral pneumonia emerged, this virus, SARS-CoV-2, a creature adjacent to the SARS virus, would go on and cause the first truly global pandemic. COVID-19, as is the official nomenclature of this pandemic.

So far, the virus has claimed 54 Lakh lives among whom 4.77 Lakhs held Indian citizenship. But the legacy of COVID pandemic cannot be completely comprehended by merely looking at the death toll, this pandemic has claimed millions of lives but has disrupted, with varying degree, the lives of all 7 billion residents of this planet.

Keeping this is in mind, the task that we set out to do and the findings of which we wish to communicate through this report was to understand and measure the disruption caused by COVID in one facet of life which we are most familiar with: Education. The relevance of studying the education infrastructure and learning experience in the COVID era is obvious; not only does it provides us with knowledge about how a significant section of society is faring in what is their primary activity, but as education significantly influences fate of an individual, studying the learning experiences also allows to get a hold of the long-term consequences of COVID.

Thus, to elucidate and compare the learning experiences of students who lived through the COVID era, we have used the paper "Students' experiences with remote learning during the COVID-19 school closure: implications for mathematics education" by Angel Mukuka, Overson Shumba and Henry M. Mulenga. This paper discloses the findings concerning math learning experience of students in Kitwe district of Zambia.

To further enrich our understanding of remote learning during COVID-19 school closure, we have also conducted a survey in the Mayurbhanj district of Odisha to find additional context for data and to simultaneously satiate our curiosity of how the Zambian reality compares to the reality in India.

We have done significant changes as compared to the Zambian research in terms of research instrumentation, statistical tools used and data analysis, the details of which follow.

Essential Demographic Details

Zambia:

- Zambia is a country of 17.35 million people; geographically speaking, it is located at Southern-Mid Africa. It is endowed with a total area of 752,617 KM square.
- It has a GDP of $75.857 billion, making the per capita income to be $4,148 in absolute terms which puts it in the category of "middle-income" countries.
- The median age of a Zambian is merely 17.6 years making it the 8th youngest nation in the world. Of the total population, 55.37% of people live in rural areas.
- However, despite having what many people would call symptoms of a poor, illiterate and under-developed society, it has an adult (15+) Literacy Rate of 86.7%, with youth literacy rate at 91.5 %, elderly literacy rate at 56.4 % and adult female literacy at 65.9 %. The government of Zambia consistently spends over 14% of its budget on education.

Odisha:

- Odisha is located along the Eastern coast of India. The province is understood to have a population of 43.7 million.
- While India has a total GDP of $2.62 trillion, Odisha makes a contribution of $71 billion to this sum. This makes the per capita income of Odisha to be $1,500 which is significantly lower than the national mean of $1900. If Odisha were a country, it would be in the category of "middle income countries".
- While the Indian Census [2011] determined median age among Indians to be around 24.9 years, among the Odia it is 26.2 years.
- The rural populace makes up a startling 83.32% of the population of Odisha.
- Adult literacy rate is understood to be at 72.9%, while rural literacy rate stands at 60.7% and urban literacy rate stands at 79.6% nationally.
- National Education Policy (2020) recommends spending 6% of the budget on education though it currently hovers around 2-3%. While provincially, Odisha spends around 14% of its budget on education.

Survey Methodology

A descriptive study method was employed that enabled the researchers to collect both quantitative and qualitative data in adherence to COVID-19 protocol.

Study Participants:

Zambia:

The survey was conducted from September 28, 2020, to October 23, 2020. This was soon after the presidential directive to re-open schools at all levels of education, with much emphasis on strict adherence to COVID-19 preventive measures as stipulated by the World Health Organisation and the country's Ministry of Health.

A cluster random sampling method was used to select the research participants from the target population involving grade 10 and grade 11 students from public secondary schools within Kitwe district. Cluster sampling was used to ensure both Urban and Peri-urban students were included in the sample with considerably similar representations. Also, Fraenkel et al. (2006, p. 95) justified that this type of sampling is one of the easiest to implement in schools, and is less time-consuming.

As per the information from the district education office, the researchers classified schools as urban if it was located within a 10km-radius from the central business district (CBD) and as peri-urban if otherwise. Thereafter, 3 schools were randomly selected from each cluster bringing the total number of participating schools to 6. From each selected school, two classes (one grade 10, and one grade 11) were randomly selected. The students in grade 9 and 12 were not selected because they were examination classes and didn't stay long enough at home during the COVID-19 lockdown. Grade-8 students were excluded because they only had less than 3 months of secondary school experience at the time of the school closure.

Odisha:

We conducted our survey from December 8, 2021, to December 13, 2021, around 4 months after the state Govt. allowed physical classes in schools. Our survey was done in the Mayurbhanj district of Odisha. It has 4 subdivisions, all identical to each other in terms of economic distribution, population, and development. Since one of our team members (Saheb Mohapatra) was a resident of the Sadara subdivision of Mayurbhanj, we decided to conduct our survey there, he being the on-field researcher.

Again, a cluster sampling method was used keeping in mind its previously-mentioned advantages. We selected 5 schools- 3 from urban and 2 from peri-urban. This selection was not completely random and was slightly

affected by the feasibility of conducting the survey within the stipulated time, particularly in the peri-urban area. A school was classified as an urban school if it was located within a 15-KM radius from the district headquarters. The rest of the schools in the subdivision were classified as peri-urban. The target participants were those currently studying in their 12th standard. This choice was driven by the following two factors-

1) We have chosen the most mature possible age group among school students; this was to ensure that the survey remains as reliable as possible (i.e., older students are supposed to be more coherent and responsible with their claims).
2) Secondly, since there is a huge incentive to do well in the 12th board examinations, we believe 12th standard students are significantly more motivated to learn than their 11th standard counterparts. So, their responses may have more propensity to the prevailing truth.

Instrumentation:

Zambia:

A semi-structured questionnaire comprising of both close-ended and open-ended question was the primary research instrument used. This is because it was considered appropriate for avoiding researchers' close and/or prolonged contact with respondents for strict adherence to COVID-19 preventive measures. The formulation of the questionnaire items was done in line with the existing literature on prospects of mathematics education during the COVID-19 pandemic (Bakker and Wagner, 2020; Engelbrecht et al., 2020a, 2020b; Olivier, 2020). For instance, the above-cited studies had raised some concerns about online lesson delivery, the associated benefits as well as the challenges that may arise due to the lack of ICT services in some settings. The formulation of questionnaire items for this study was also inspired by the government's response to COVID-19 school closure and the anticipated challenges associated with remote learning in Zambia.

Prior to the main data collection, the Zambian researchers sent a draft questionnaire to the experts for validation. These experts comprised 2 Ph.D. students in mathematics education, 2 master's students in mathematics education, 6 college/university lecturers in mathematics and science education, and 5 secondary school teachers of mathematics. They were asked to comment on the quality of the included items in terms of sufficiency, relevance, clarity, and coherence. Their feedback, suggestions and comments were

analysed and the final questionnaire was developed.

Their questionnaire comprised three sections namely, demographic information, students' access to mathematics learning during the COVID-19 school closure, and the challenges associated with the available mathematics learning options during that time. The questionnaire and the associated datasets are openly available at https://doi.org/10.17632/mb8sdf576c.1.

Odisha:

We used the exactly similar approach as done by our Zambian counterparts. Before designing the questionnaire, our on-field researcher (Saheb Mohapatra) interviewed few students of grade 12 randomly to discuss what their learning options were and what had affected their mathematical learning during the lockdown. Then, inspired by this, we developed a questionnaire and sent it to senior students and few teachers to scrutinize its relevance, usefulness and un-ambiguity.

For the urban schools, we selected 3 schools and then sent our google form in their class WhatsApp groups. We ensured before doing this that all the students of the respective schools are a part of these groups and are considerable active enough to get to know about our survey.

For the peri-urban case, the on-field researcher had to physically go to the 2 selected schools. We then interviewed the students there and filled it in our google form. This was impossible without the support of the teachers in those schools.

The questionnaire is openly available at Google form.pdf - Google Drive.

Changes made in our questionnaire:

1) In order to get an insight of the role of annual family income in our study, we decided to include this among the questions regarding their demographic details.
2) We have changed the list of possible learning options and factors affecting learning in response to the changes in Govt. action in the Indian context.
3) We also included a question to know if the students were aware of the Govt. e-learning platforms. This would throw insight on the implementation of the Govt. decisions during COVID-19 school closure.

To add to 2), we have added a crucial factor in the list of factors affecting learning, namely,

"Distraction in online mode". This includes activities like changing tabs while online class, playing games, YouTube etc; and short attention span while attending classes online. Another major change was to include the factor – "Lack of a proper study environment at home (due to noise and other disturbances, etc.)". This is in response to what we got after interviewing few students before designing the final questionnaire.

Basic Overview of the Data

Zambia:

- In Zambia, a sample of size 367 was collected which consists of 176 urban students and 191 peri-urban students from grades 10th and 11th.
- There were 189 females and 178 males.
- The ages of respondents ranged from 13 to 21 (Mean = 16.92, SD=1.47). It was further noted that 174 (47.4%) respondents were in their 10th grade while 193 (52.6%) were doing grade 11.
- As evident from the bar plots, a majority (78.1%) of the students preferred self-study using hard copies much more than the other options. This was followed by the televised mathematics lessons that were used by 43.3% of the respondents, while private lessons provided by mathematics teachers at home (34.2%) were the third most used learning mode.
- Results further revealed that 21.8% of the respondents (25.9% urban and 18.2% peri-urban students) used the recently launched e-learning and smart revision portals, while only 19.7% were able to learn mathematics through lessons provided by their teachers online.
- Private lessons provided by mathematics teachers to students in their respective homes was another learning option that was preferred by a substantial number of students from both urban schools (15.4%) and peri-urban schools (9.4%).
- The least used learning option for both urban (5.8%) and peri-urban (4.3%) was through the lessons broadcasted by the radio.

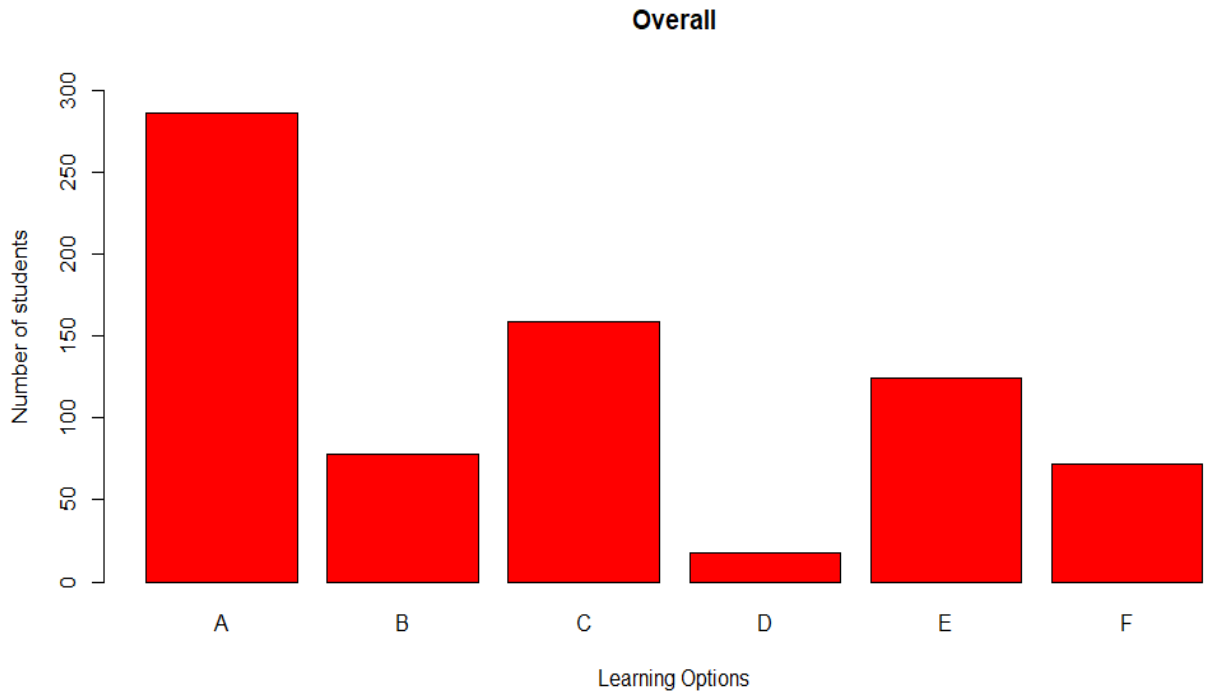
A	Self-study using hard copies of mathematics textbooks, notebooks, etc.
B	Self-study using e-Learning and Smart Revision portals
C	Televised mathematics lessons on ZNBC's TV4 channel
D	Mathematics lessons on the radio
E	Private lessons provided by a mathematics teacher at home
F	Online lessons that were provided by mathematics teachers.

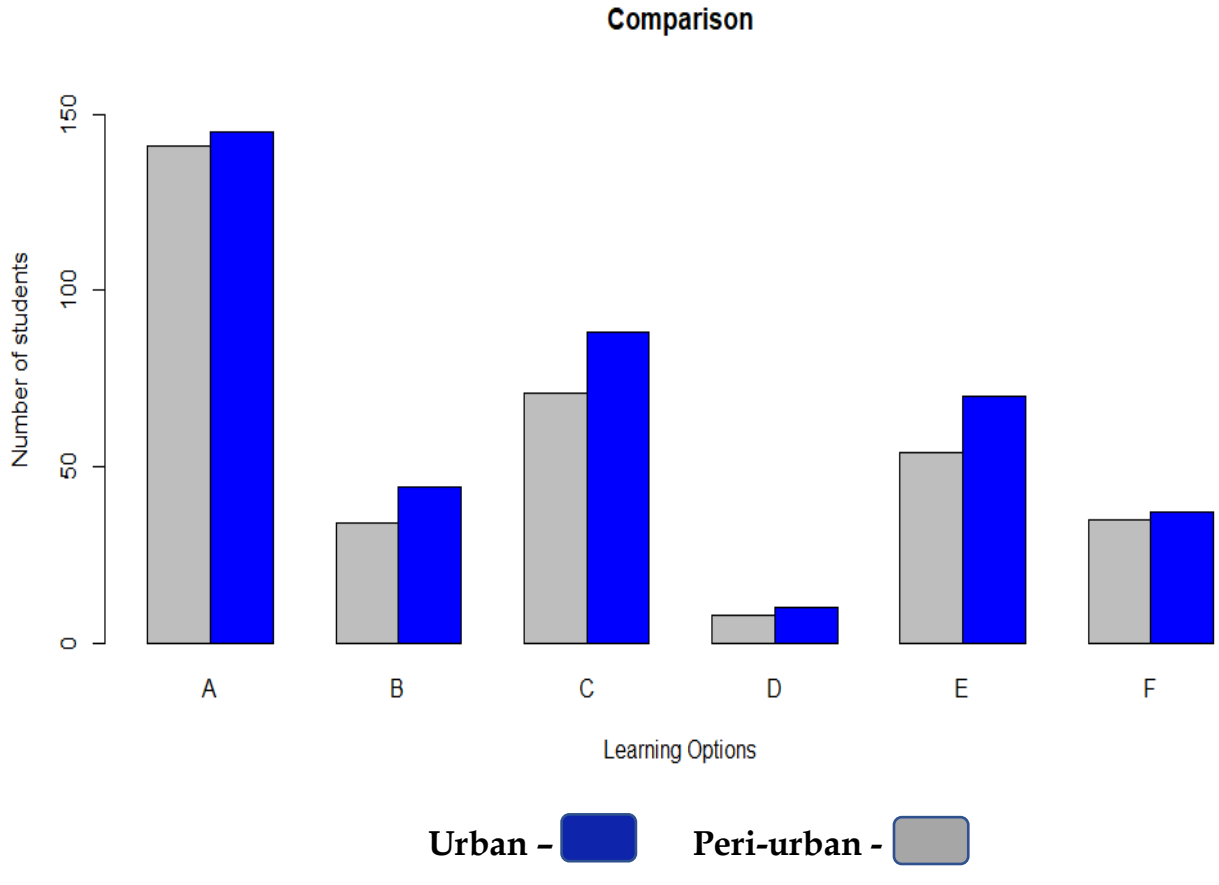
Table 1. Accessible mathematics learning options during the COVID-19 school closure (Zambia)[References-1]

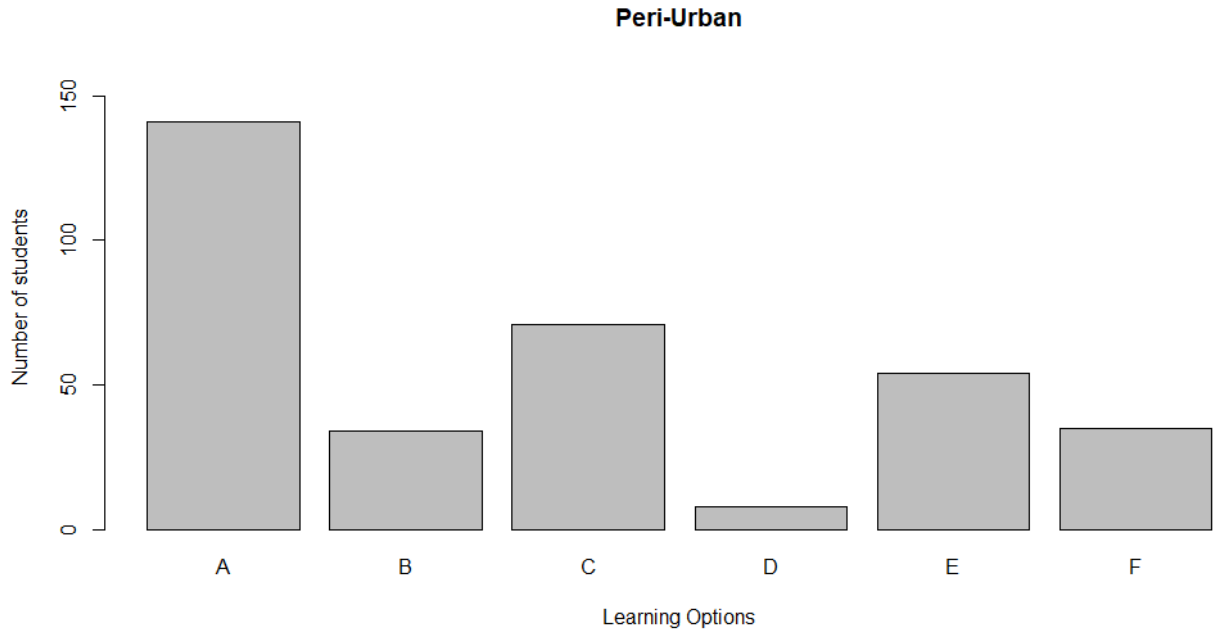
How were you learning mathematics during the COVID-19 school closure?	School Type	Number of Learners (N)	Response	
			Yes N(%)	No N (%)
A. Self-study using hard copies of mathematics textbooks, notebooks, etc.	Urban	175	145 (82.9)	30 (17.1)
	Peri - Urban	191	141 (73.8)	50 (26.1)
	Total	366	286 (78.1)	80 (21.9)
B. Self-study using e-Learning and Smart Revision portals	Urban	170	44 (25.9)	126 (74.1)
	Peri - Urban	187	34 (18.2)	153 (81.8)
	Total	357	78 (21.8)	279 (78.2)
C. Televised mathematics lessons on ZNBC's TV4 channel	Urban	176	88 (50)	88 (50)
	Peri - Urban	191	71 (37.2)	120 (62.8)
	Total	367	159 (43.3)	208 (56.7)
D. Mathematics lessons aired on the radio	Urban	172	10 (5.8)	162 (94.2)
	Peri - Urban	182	8 (4.3)	177 (95.7)
	Total	357	18 (5.0)	339 (95.0)
E. Private lessons provided by a mathematics teacher at home	Urban	174	70 (40.2)	104 (59.8)
	Peri - Urban	189	54 (28.6)	135 (71.4)
	Total	363	124 (34.2)	239 (65.8)
F. Online lessons that were provided by mathematics teachers	Urban	174	37 (21.3)	137 (78.7)
	Peri - Urban	191	35 (18.3)	156 (81.7)
	Total	365	72 (19.7)	293 (80.3)

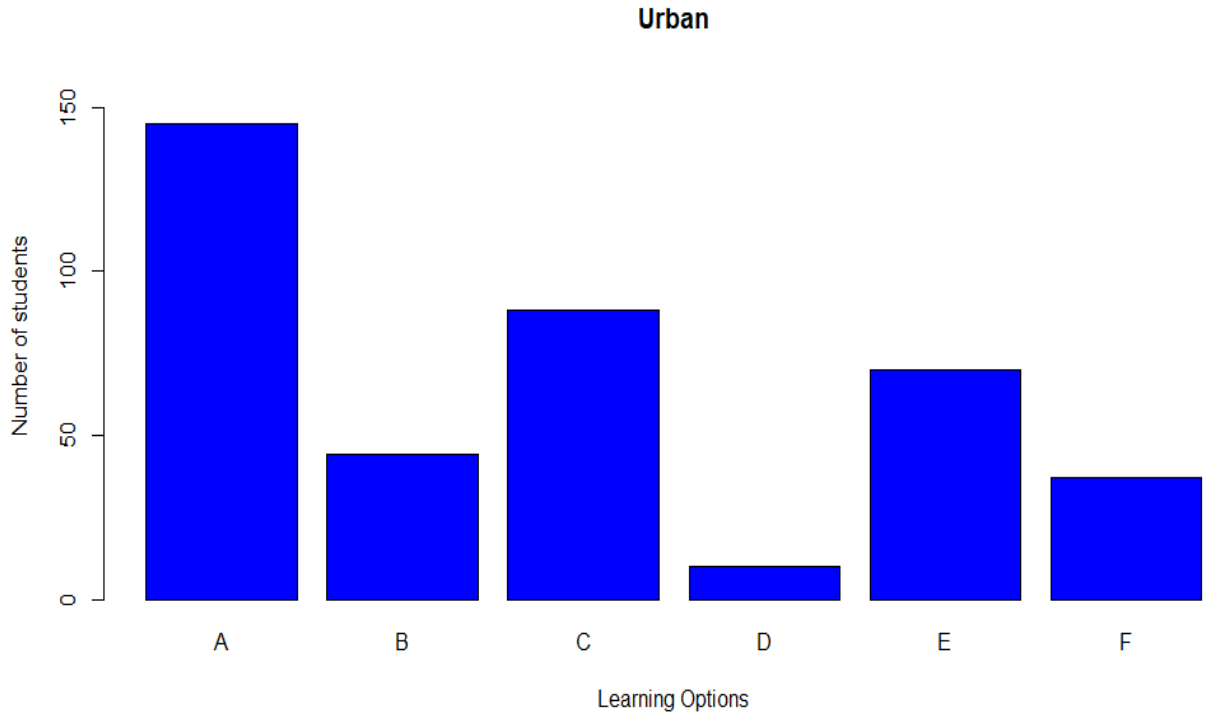
Table 2. Factors affecting students mathematical learning during the COVID-19 school closure (Zambia)[References-1]

Factors	School Type	Number of Learners (N)	Response	
			Affected	Not Affected
A. Lack of electricity	Urban	176	100 (56.8)	76 (43.2)
	Peri - Urban	191	130 (68.1)	61 (31.9)
	Total	367	230 (62.7)	137 (37.3)
B. Irregular supply of electricity	Urban	175	131 (74.9)	44 (25.1)
	Peri - Urban	190	161 (84.7)	29 (15.3)
	Total	365	292 (80.0)	73 (20.0)
C. Lack of television (TV) set	Urban	173	54 (31.2)	119 (68.8)
	Peri - Urban	191	94 (49.2)	97 (50.8)
	Total	364	148 (40.7)	216 (59.3)
D. Lack of a radio	Urban	173	54 (31.2)	119 (68.8)
	Peri - Urban	184	79 (42.9)	105 (57.1)
	Total	357	133 (37.3)	224 (62.7)
E. Lack of ICT gadgets like smartphones, computers, etc.	Urban	169	114 (67.5)	55 (32.5)
	Peri - Urban	190	131 (68.9)	59 (31.1)
	Total	359	245 (68.2)	114 (31.8)
F. Irregular TV channel subscriptions	Urban	173	94 (54.3)	79 (45.7)
	Peri - Urban	185	114 (61.6)	71 (38.4)
	Total	358	208 (58.1)	150 (41.9)
G. Lack of mathematics textbooks and other learning materials	Urban	173	140 (80.9)	33 (19.1)
	Peri - Urban	190	146 (76.8)	44 (23.2)
	Total	363	286 (78.8)	77 (21.2)
H. Lack of a more knowledgeable person to explain certain mathematical concepts	Urban	175	137 (78.3)	38 (21.7)
	Peri - Urban	191	150 (78.5)	41 (25.5)
	Total	366	287 (78.4)	79 (21.6)
I. Lack of internet access	Urban	174	110 (63.2)	64 (38.8)
	Peri - Urban	189	141 (74.6)	48 (25.4)
	Total	363	251 (69.1)	112 (30.9)
J. Limited access to the internet	Urban	173	124 (71.7)	49 (28.3)
	Peri - Urban	191	154 (80.6)	37 (19.4)
	Total	364	278 (76.4)	86 (23.6)

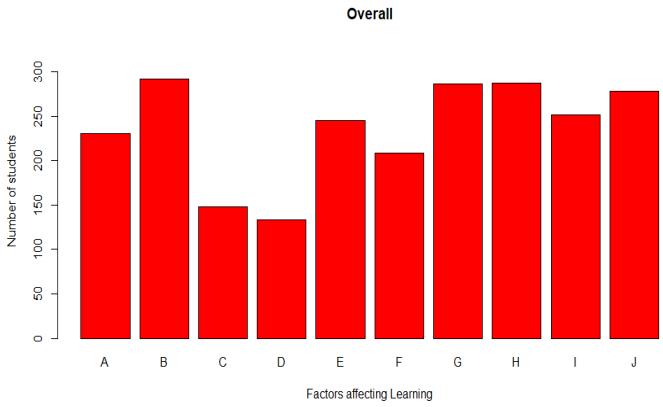

Overall
Number of students
0
50
100
150
200
250
300
A
B
C
D
E
F
Learning Options

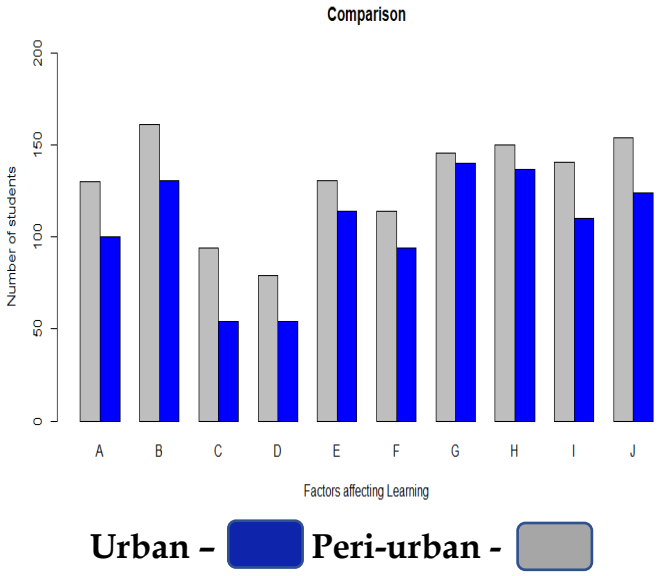

Comparison
Number of students
0
50
100
150
A
B
C
D
E
F
Learning Options
Urban –
Peri-urban -


Peri-Urban
Number of students
0
50
100
150
A
B
C
D
E
F
Learning Options


Urban
Number of students
0
50
100
150
A
B
C
D
E
F
Learning Options

- Now, on analysing the factors affecting learning, we observed that the number of students who were affected by 8 of the 10 factors was more than the number of students who indicated that they were not affected.
- Only the lack of a television set and lack of radio seemed to have affected a smaller number of students compared to those who were not affected.
- In terms of the geographical location of the sampled schools, results indicate that more students from peri-urban schools were affected by each of the 10 factors compared to their counterparts from urban schools. This could be attributed to the fact that urban students had more access to various learning options than their counterparts from peri-urban schools.
- Further analysis is covered later using the Pearson's Chi-square test.





A	Lack of electricity.
B	Irregular supply of electricity
C	Lack of television (TV) set
D	Lack of a radio
E	Lack of ICT gadgets like smartphones, computers, etc.
F	Irregular TV channel subscription

G	Lack of mathematics textbooks and other learning materials
H	Lack of a more knowledgeable person to explain certain mathematical concepts
I	Lack of internet access
J	Limited access to the internet

Odisha:

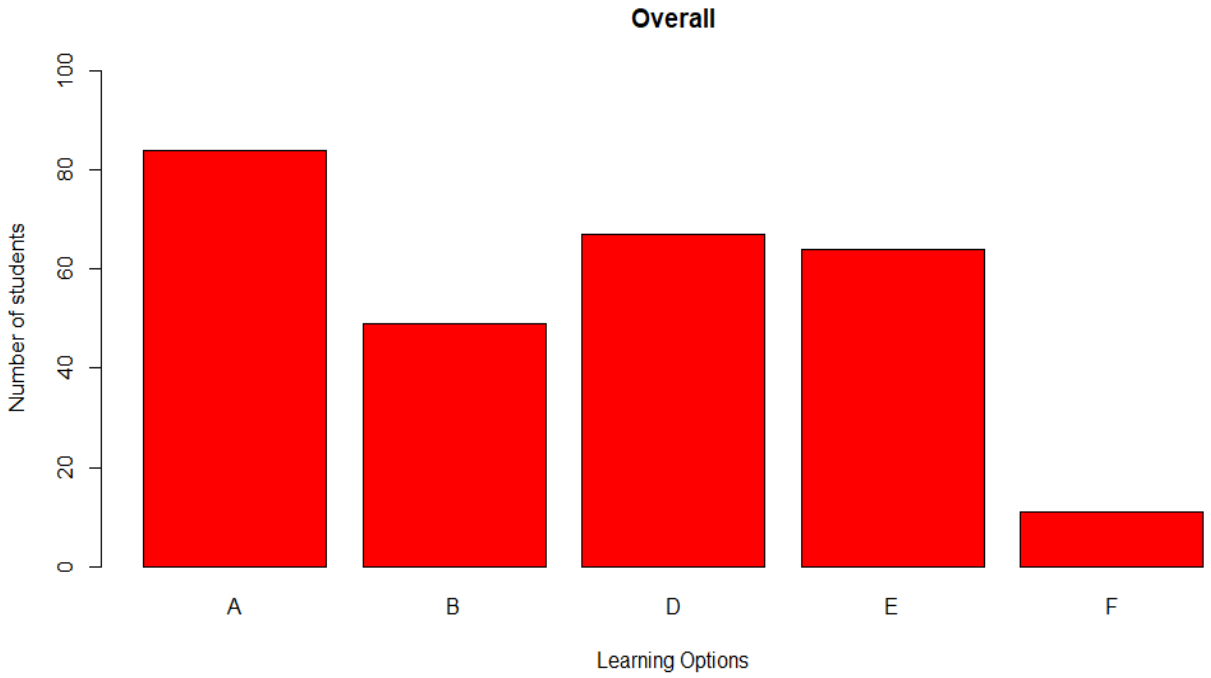
- The total number of people surveyed were 133. Of them 84 were male while 49 were female.
- Moreover, 67 lived in peri-urban household while 65 lived in urban household.
- Of the total 133 students. 23 lived in households earning upward of 6 lakhs, 33 lived in households earning between 2 to 6 lakhs, finally 77 students lived in earning less than 2 Lakhs. Thus, the majority of people earned less than 2 Lakhs which is in line with per capita income of the country, also this aligns well with the poor economic face of Mayurbhanj and the state Odisha as well.
- The plot shows, most students used Mathematics textbooks and test-papers to learn mathematics during COVID-19 school closure (about 64%).
- Private e-Learning platforms were the second most used option (about 50%).
- A small proportion of people in the sample were using Govt. e-learning platforms and lessons broadcast on TV (3% and 8% respectively).
- Our data further revealed that out of 133 respondents, 81 respondents were unaware of the Govt. e-learning platforms.
- In survey questionnaire, they were asked to select the most beneficial learning option among the options they were using. Responses to that question revealed that private e-learning platforms were the most beneficial learning option (28%).
- However, for the urban students, private tuition teachers and online lessons (33%) were the most beneficial and in the peri-urban case, online lessons were the most beneficial (29%).
- Govt. e-learning Platforms were beneficial to none (0%).
- Among the urban the most and least used learning method remained the same as for the overall data, but for the rest of the data two interesting trends emerged. The percentage of students using private e-learning or online classes by school remained the same across the groups but there was a substantially lesser number of people among urban students who depended on self-study, in contrast to hiring of private tutors that seems to be very popular among the urban students in comparison to peri-urban ones.

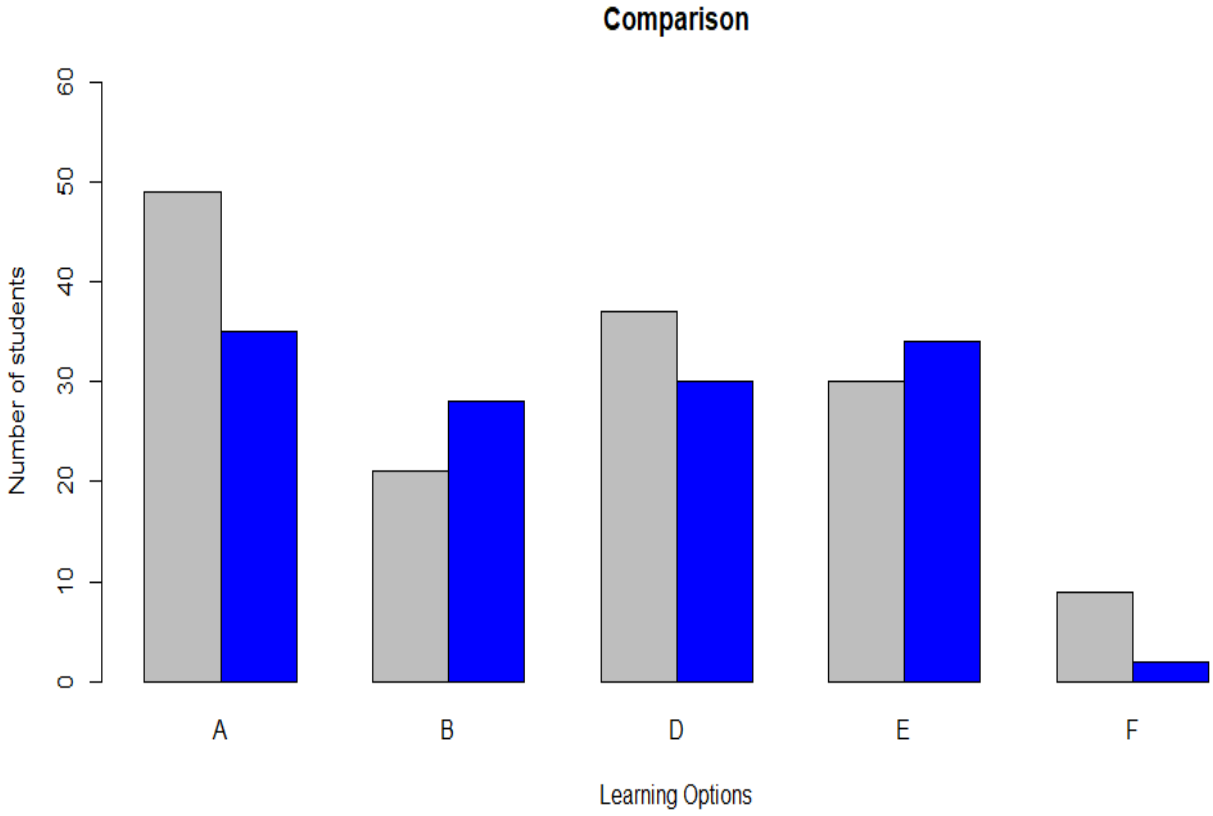
Table 3. Learning options used by the students (Odisha)

How were you learning mathematics during the COVID-19 school closure?	School Type	Response	
		Yes	No
A. Studied on my own from Mathematics textbooks and test-papers	Urban	35	30
	Peri - Urban	49	19
	Total	84	49
B. Private tuition teacher or coaching centres	Urban	28	37
	Peri - Urban	21	47
	Total	49	84
C. Govt. e-learning platforms (SWAYAM, Diksha Portal, e-Pathshala, National Repository of Open Educational Resources, etc.)	Urban	1	64
	Peri - Urban	3	65
	Total	4	129
D. Private e-Learning platforms (Unacademy, Byju's, etc.) and/or YouTube	Urban	30	35
	Peri - Urban	37	31
	Total	67	66
E. Online lessons by school teachers through Zoom, Google Meet, WhatsApp etc	Urban	34	31
	Peri - Urban	30	38
	Total	64	69
F. Lessons broadcast on Television	Urban	2	63
	Peri - Urban	9	59
	Total	11	122

Factors Affecting Students' Learning	School Type	Response	
		Affected	Not Affected
A8. Lack of Classroom environment	Urban	38	27
	Peri - Urban	48	20
	Total	86	47
B8. Lack of a proper study environment at home (due to noise and other disturbances, etc.)	Urban	31	34
	Peri - Urban	29	39
	Total	60	73
C8. Unavailability of private tutors, Coaching centres	Urban	6	59
	Peri - Urban	31	37
	Total	37	96
D8. No or Poor internet connectivity	Urban	15	50
	Peri - Urban	26	42
	Total	41	92
E8. Teachers were technologically unskilled, so inefficient teaching	Urban	11	54
	Peri - Urban	13	55
	Total	24	109
F8. Lack of gadgets like Smartphones, Laptops, etc	Urban	8	57
	Peri - Urban	17	51
	Total	25	108
G8. Distraction in online mode (for example switching to other tabs like browsing YouTube, WhatsApp, etc while in class, short attention span in online class, etc.)	Urban	47	18
	Peri - Urban	22	46
	Total	69	64

Table 4. Factors Affecting Students' Learning (Odisha)

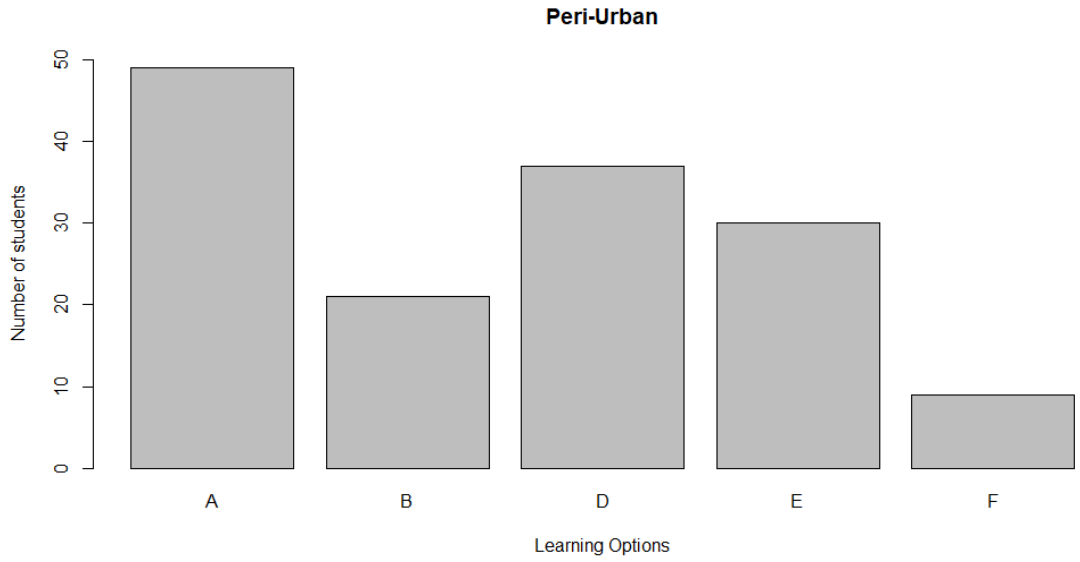


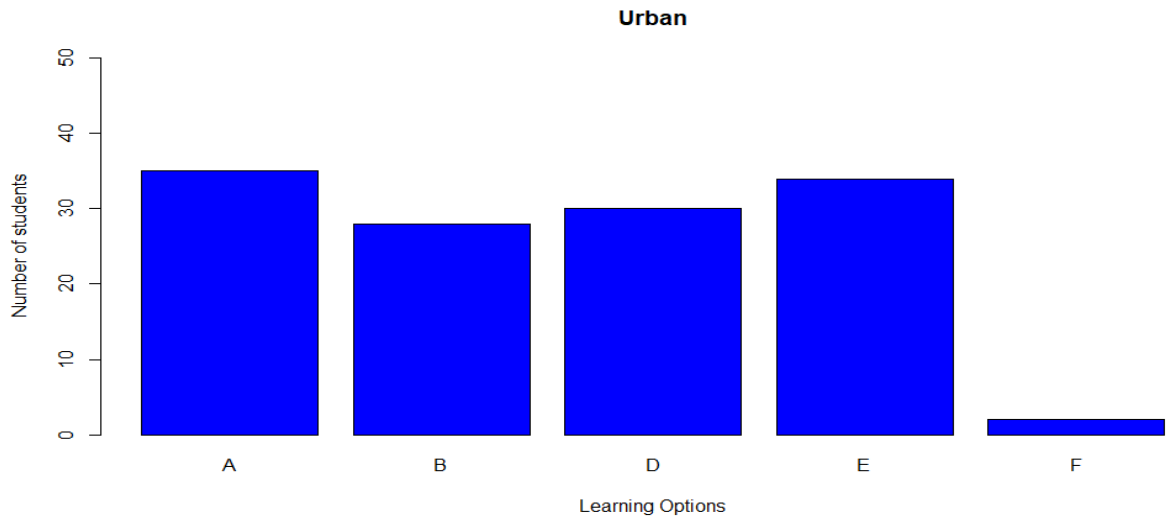


Urban – **Peri-urban -**

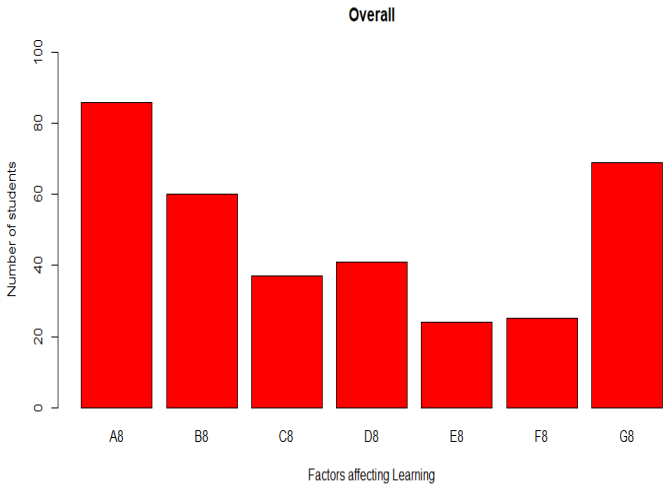
We haven't included the learning option C in the bar-plots because of its extremely small count which when included hides the count differences between other learning options.

A	Studied on my own from Mathematics textbooks and test-papers
B	Private tuition teacher or coaching centres
C	Govt. e-learning platforms (SWAYAM, Diksha Portal, e-Pathshala, National Repository of Open Educational Resources, etc.)
D	Private e-Learning platforms (Unacademy, Byju's, etc.) and/or YouTube
E	Online lessons by school teachers through Zoom, Google Meet, WhatsApp etc
F	Lessons broadcast on Television



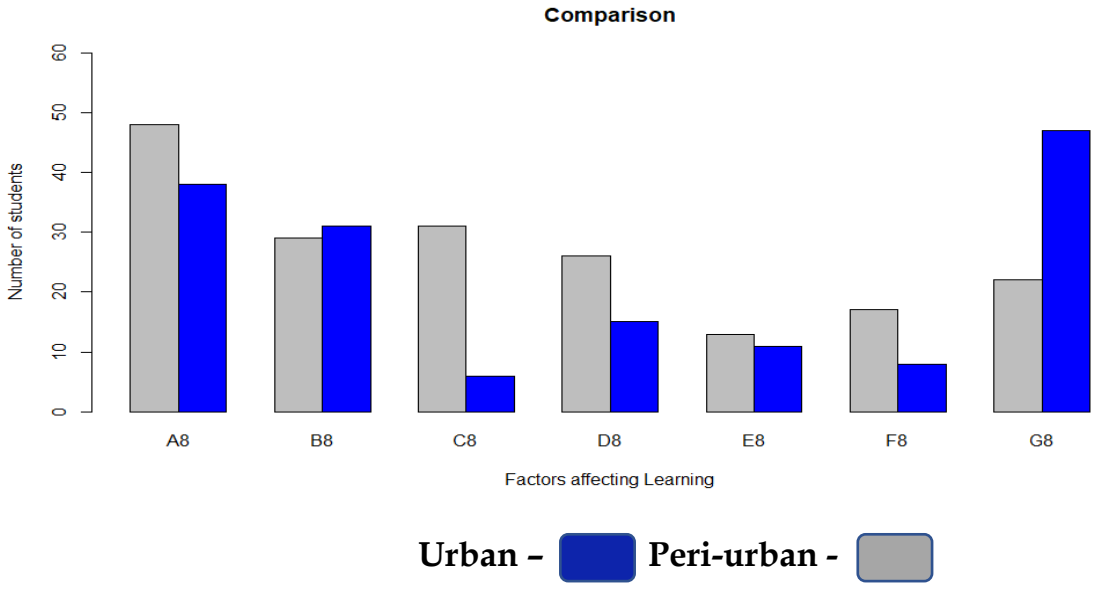


- Now, on analysing the factors affecting Mathematical learning in Odisha, we get lack of classroom environment affected most of the respondents (64%).
- Second most affecting factor was "Distraction in online mode" (51%). Most of the urban students were affected by "Distraction in online mode" (72%).
- Lack of electricity affected a very small proportion of the sample (4%).
- Lack of gadgets affected 18% of the respondents (12% in urban) and (25% in Rural).
- In terms of the geographical location of the sampled schools, the Comparison Bar plot shows that more students from peri-urban schools were affected by all factors compared to their counterparts from urban schools, except for B8 and G8.
- An interesting trend was noticed in which lack of tutors was the second major concern of peri-urban students while only 6 urban students were concerned. Lack of a study environment at home and lack of technical comfortability from teacher's part was another issue against which both categories felt apathetic towards.

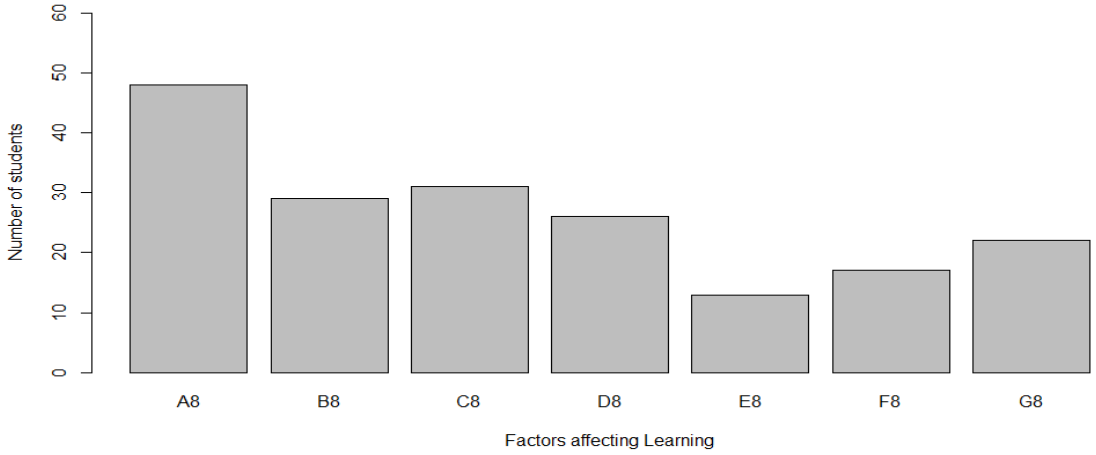


A8	Lack of Classroom environment
B8	Lack of a proper study environment at home (due to noise and other disturbances, etc.)
C8	Unavailability of private tutors, Coaching centres
D8	No or Poor internet connectivity
E8	Teachers were technologically unskilled, so inefficient teaching
F8	Lack of gadgets like Smartphones, Laptops, etc.
G8	Distraction in online mode (for example switching to other tabs like browsing YouTube, WhatsApp, etc. while in class, short attention span in online class, etc.
H8	Lack of electricity

We haven't included the factor H8 in the bar-plots because of its extremely small count which when included hides the count difference between other factors.



Urban – Peri-urban -



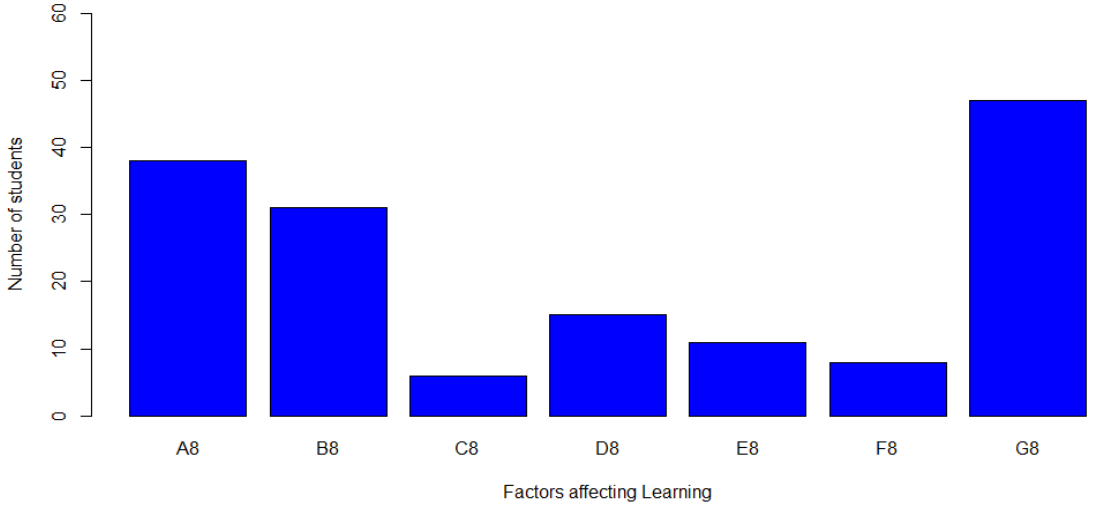


Table 5. Pearson Chi-square tests of Association between School Type and each of the Factors (Zambia)-References-1

Factors	Chi Square and DF	P - Value
A. Lack of electricity	4.951, df = 1	0.026
B. Irregular supply of electricity	5.557, df = 1	0.018
C. Lack of television (TV) set	12.191, df = 1	0.000
D. Lack of a radio	5.240, df = 1	0.022
E. Lack of ICT gadgets like smartphones, computers, etc.	0.092, df = 1	0.762
F. Irregular TV channel subscriptions	1.950, df = 1	0.163
G. Lack of mathematics textbooks and other learning materials	0.903, df = 1	0.342
H. Lack of someone to explain certain mathematical concepts	0.003, df = 1	0.954
I. Lack of internet access	5.504, df = 1	0.019
J. Limited access to the internet	4.032, df =1	0.045
Table 6. CI for LOG odds ratio (factors affecting learning – Rural VS Urban -Odisha)		

Factors	Odds Ratio	95 % CI for log (Odds Ratio)
A8. Lack of Classroom environment	0.5864198	(-1.2516823, 0.18424337)
B8. Lack of a proper study environment at home (due to noise and other disturbances, etc.)	1.2261663	(-0.4801142, 0.88789919)
C8. Unavailability of private tutors, Coaching centres	0.1213778	(-3.0748151, -1.14287944)
D8. No or Poor internet connectivity	0.4846154	(-1.4807979, 0.03199842)
E8. Teachers were technologically unskilled, so inefficient teaching	0.8618234	(-1.0351039, 0.73769406)
F8. Lack of gadgets like Smartphones, Laptops, etc	0.4210526	(-1.7863374, 0.05634249)
G8. Distraction in online mode (for example switching to other tabs like browsing YouTube, WhatsApp, etc while in class, short attention-span in online class, etc.)	5.4595960	(0.9535541, 2.44119552)
H8. Lack of electricity (Extremely low counts)	----	----

Statistical Analysis Of the learning options

Null hypothesis: Student's learning preferences are independent of their geographical locations.

Zambia:

- First of all, we analyse the dependence of a student's geographical location and the learning options they used for Mathematics. To know more about this dependence, we did the Chi-Square test for independence which wasn't originally done by the Zambian researchers.
- The test couldn't reject the null hypothesis for the factors- Self-study using e-Learning and Smart Revision portals (Chisq – 3.0924, p-value – 0.07866), Mathematics lessons aired on the radio (Chisq – 0.4131, p-value – 0.5204) and Online lessons that were provided by mathematics teachers (Chisq - 0.49693, p-value – 0.4809). Hence, we can't infer any dependence of student's geographical location and the preference of these learning options.
- However, for the following learning option— Self-study using hard copies of mathematics textbooks, notebooks, etc. (Chisq – 4.3648, p-value – 0.03669), Televised mathematics lessons on ZNBC's TV4 channel (Chisq – 6.1379, p-value – 0.01323) and Private lessons provided by a mathematics teacher at home (Chisq – 5.3125, p-value – 0.02117), there was indeed a significant (at 5% level) dependence. Moreover, looking at the bar plots, it was evident that in all of these 3 options, the urban students preferred them more than those in peri-urban areas.
- There could be several reasons for this. The most obvious being- "since the peri-urban students were more economically deprived, they may not have afforded a TV or even a private tutor, unlike their urban counterparts."

  This is supported by one of the answers to the open-ended questions:

  Respondent 39: Since my parents cannot afford to buy a TV set or pay for extra lessons, studying on my own was a better and easier way to learn mathematics.

  The same could not have happened in the case of textbooks as they were very cheap. There may be a poor supply of textbooks in peri-urban areas. But all these reasons can be more supported after we analyse the data regarding factors affecting their Mathematics learning and perform thematization on the open-ended question.

- Analysis of open-ended questions revealed that those who preferred self-study from textbooks, justified their choice by stating that it was cheap and could be used any time as per their will for studying. A recurring theme in the open-ended question shows that a lot of students believed that there should be someone to teach them Math, and were under-confident about handling it on their own.

These responses support it—-

Respondent 293: I understand mathematics more when there is someone to explain and correct me where I go wrong.

Respondent 358: Private lessons provided by mathematics teachers at home were beneficial to me because I was able to ask where I was wrong and where I did not understand.

Respondent 63: Studying mathematics on my own was not good. I was separated from my friends and my teacher because of social distancing and I had no one to ask about things I did not understand.

- A majority of the respondents indicated that they found none of those learning methods useful because mathematics was generally difficult for them. This shows their negative attitude towards Math and their state of under-confidence.

Odisha:

- While analysing the counterpart of the above for Odisha, the Chi square test showed significant dependence in the two learning options— self-study using books (A) and learning from televised lessons (F). In fact, in both of these situations, the results were totally opposite of the Zambian case. We saw that the peri-urban students preferred them more than the urbans. One plausible cause can be "peri-urban students couldn't have afforded private tutors and may have relied only on self-study". The same could have happened for televised lessons. This is supported by the distribution of economic levels in both peri-urban and urban cases.
- Learning from television was very popular among the peri-urban students.

Response 56: Because of Covid-19 Pandemic, as I belong to a poor family, I can't afford a private or personal teacher or institutions for me. So, I had to find another option, then during the Pandemic I chose self-study and thanks to govt. for allotting television like teaching stuff for us. It really helped me and the other students to find another way to study during the Covid19 pandemic.

- Also, a lot of peri-urban students preferred online classes stating that those were well-conducted and regular.
- There were two themes in the open-ended questions. The most dominating was that most of the urban students chose YouTube stating the freedom they get there and how cheap it is.

Response 80: It was a great help from YouTube as it allows us to choose our teachers.

Response 69: The free lectures were extremely beneficial to me. The YouTube lectures were cost saving and an efficient way of learning.

Response 64: I started with self-study, but soon I realized that it's a tedious and time-consuming task to do it all alone. So, I watched lectures on YouTube and then read from books. It increased my retention of the subject matter.

- One more recurring theme was that of private teachers and coaching centres, being justified by their one-to-one correspondence and doubt clearing sessions.

- Apart from the above, there was one highly recurrent theme in both urban and peri-urban areas, it was that most of the students relied on their family members or neighbours to teach them Mathematics.
- One crucial part of our survey was to get an idea of how popular the Govt. e-learning platforms were amongst students, and if they were aware of them. Surprisingly, around 60% of them weren't aware of these, especially the urban ones. Even among those who were aware, a total of only 5 students of the 133, used these platforms. This unveils a lacuna in the government's efforts to promote these platforms and also make them student friendly similar to the multitude of them in YouTube or other private learning platforms.

Learning Option	Chisq value	p-value
A	4.737	0.02951
B	2.1239	0.145
C	---	---
D	0.9066	0.341
E	0.8929	0.3447
F	4.52	0.03349

Table 7

Learning Option	Confidence interval for log odds ratio
A	(-1.5132194, -0.073241920)
B	(-0.1841986, 1.238022123)
C	-------
D	(-1.0133906, 0.351227803)
E	(-0.3539104, 1.011434610)
F	(-3.1424567,0.003107307)

Table 8

Odisha-Urban-vs-Peri-urban (Learning Options)

Table 9. (Factors affecting Learning-Urban VS Peri-urban-Odisha)

Factors	Chi Square Value and DF	P - Value
A8. Lack of Classroom environment	2.1388, df = 1	0.1436
B8. Lack of a proper study environment at home (due to noise and other disturbances, etc.)	0.3416, df = 1	0.5589
C8. Unavailability of private tutors, Coaching centres	21.877, df = 1	2.907e-06
D8. No or Poor internet connectivity	3.581, df = 1	0.05844
E8. Teachers were technologically unskilled, so inefficient teaching	0.10823, df = 1	0.7422
F8. Lack of gadgets like Smartphones, Laptops, etc	3.507, df = 1	0.06109
G8. Distraction in online mode (for example switching to other tabs like browsing YouTube, WhatsApp, etc while in class, short attention span in online class, etc.)	21.251, df = 1	4.029e-06
We haven't included the factor H8 in Table 9 and Table 10 because of its extremely low counts.		
Table 10-Factors affecting Learning (Income level-Odisha)		
Factors	**Chi Square Value and DF**	**P - Value**
A8. Lack of Classroom environment	0.65959, df = 1	0.4167
B8. Lack of a proper study environment at home (due to noise and other disturbances, etc.)	0.067632, df = 1	0.7948
C8. Unavailability of private tutors, Coaching centres	14.094, df = 1	0.0001739
D8. No or Poor internet connectivity	1.5402, df = 1	0.2146
E8. Teachers were technologically unskilled, so inefficient teaching	0.25478, df = 1	0.6137
F8. Lack of gadgets like Smartphones, Laptops, etc	4.14, df = 1	0.04188
G8. Distraction in online mode (for example switching to other tabs like browsing YouTube, WhatsApp, etc while in class, short attention span in online class, etc.)	14.807, df = 1	0.0001191

Statistical Analysis of the Factors affecting Mathematical learning

Now, we analyse how different factors that affected Mathematical learning were dependent on the students' geographical locations.

Zambia:

- In case of Zambia, chi-square test clearly shows that there were no statistically significant results on the association of student's geographical locations and the factors —Lack of ICT gadgets like smartphones, computers, etc., Irregular TV channel subscriptions., Lack of mathematics textbooks and other learning materials and Lack of someone to explain certain mathematical concepts.
- Significant association (Table 5) was found in-

1. Lack of electricity

(Chisq-4.951, p- .026)

2. Irregular supply of electricity

(Chisq-5.557, p- .018)

3. Lack of television (TV) set

(Chisq-12.121, $p < 0.0001$)

4. Lack of a radio

(Chisq-5.240, p-0.022)

5. Lack of internet access

(Chisq-5.504, p-0.019)

6. Limited access to the internet

(Chisq- 4.032, $p < 0.045$)

- Looking at the bar plots, we see that indeed, the peri-urban students were affected much more than the urban ones in the case of these factors. This immensely supports our earlier reasoning that the peri-urban students couldn't afford a TV. Moreover, lack or limited access to the internet is detrimental for a smooth remote learning experience.

Odisha:

- On the other hand, the data of Odisha shows statistically significant association between student's geographical location and the factors affecting study namely —

1. Lack of private tutors, coaching centres
2. Distraction in Online mode

- What we observed on analysing the odds ratio was that the students in peri-urban areas were much more affected by the lack of private tutors, coaching centres as compared to their urban counterparts. This greatly supports our earlier observation that the peri-urban students greatly preferred self-study as compared urban. Quite possible is that, just because they can't afford private tutors and coaching centres which now-a-days charge a lot of money, they

have no option other than self-study.

Now, one question arises— If not the private tutors or coaching centres which are costly, why can't the peri-urban students incline towards private-e-learning platforms or YouTube etc.?

One plausible reason is unawareness about these platforms. But what's more convincing is that, solely depending on YouTube isn't considered sufficient by many students because of their negative attitude towards the subject. This might not have happened in urban cases as those students may have used a mixture of private tutors and YouTube or other private e-learning platforms.

- No or Poor internet connectivity and lack of gadgets like smartphone, laptop etc - these 2 factors did not show statistically significant association at 5% level; however, their p-values were right near the margin. In fact, at 10% significance level, they showed association. This observation can be backed up by our thematization results of the open-ended questions in peri-urban areas. A common theme that persists there is that of lack of gadgets and poor connectivity.
- Secondly, we decided to perform the same chi-square test with annual family income — with the 2 levels being - below 2 lakhs and above 2 lakhs. What we observed was akin to our earlier results that the economically poor students faced the problems of lack of private coaching and tutors. But what's more important is that even with a 5% significance level "Lack of gadgets" was indeed a factor associated with those with annual family income less than 2 lakhs. This clearly calls for the need to boost manufacturing of gadgets so that they become cheap. This should be government-sponsored.
- What's more interesting is that there was a huge dependence on urban people and distraction in online mode as evident from the results of chi-square test and odd ratio. By distraction, we mean students changing tabs while attending lectures, having short attention spans and so on. This is a matter of huge concern and should be taken care of by the guardians of the students.
- The open - ended questions in case of urban people shows that there was a recurrent theme of disturbance at home and being distracted during online classes.

Response 39: As we all belong to a middle-class family so disturbance while studying is common.

- One more theme to be pointed out was that – Urban Students believed mathematics was better learnt on face-to-face interactions and they faced difficulty in solving "Higher order thinking problems" on their own, in particular.

Solutions and Discussion:

Zambia:

This study explored secondary school students' experiences with mathematics remote learning during the COVID-19 school closure. A switch to a remote learning option during the COVID-19 school closure was good for the continuous provision of education to all learners of school mathematics and other subjects. However, the findings of this study have provided evidence that the implementation of such a measure might have been hampered by some challenges.

While educators from some technologically advanced countries might be managing to reach out to their learners through an online mode of lesson delivery, some low-income countries may find remote learning quite difficult. This could be attributed to limited resources by most schools and a lack of experience by the vast majority of teachers with online teaching modes.

We can argue that COVID-19 school closure in Zambia, and elsewhere could be a wake-up call for education systems to put up infrastructure that supports the blended and online learning modes. The provision of ICT products and services is bound to make the teaching of mathematics easier, both remotely and during physical classroom interactions.

The researchers provided the following solutions:

- First, education providers should always consider the social and economic status of learners when designing instructional strategies. The education system worldwide should take advantage of the COVID-19 outbreak to bridge the gap between the rich and the poor in terms of access to quality education.
- Second is a need to provide ICT products and services to all learners regardless of their socio-cultural and economic status. If such products and services are not provided to all then our students in the rural and other underprivileged communities will lag. However, providing access to ICT services to all

students is not attainable within a short period because it requires a lot of resources from the government and other stakeholders. Because of this, schools that are unable to provide e-learning services to their students may scale up the printing of study materials and devise a mechanism for the distribution of such materials to their students.

- But above all, even after study materials reach to most of the students, they may not be able to understand them solely by themselves. Even with the assistance of teachers, they may lag behind if the quality of education in online mode is poor. So, teachers should be trained well to deal with this new scenario. They should carefully revamp their strategies so that the students properly benefit.
- There is a need for each school to design its virtual and/or a physical mathematics laboratory that is fully equipped with learning materials, mathematical games, and various teaching and learning aids. Social media platforms such as Facebook, WhatsApp, Twitter, and so forth where teachers and students can interact could be established in all schools.
- Lastly, the students mental state that is over-laden with under-confidence and negative attitude towards mathematics should be addressed. They should be motivated to learn this subject even when there is no one present to explain. This can be done by using interactive and modern models for teaching instead of sticking to the traditional means.

Odisha:

The situation in Odisha wasn't very different in terms of peri-urban students' limited access to internet and gadgets. Also, prevalence of expensive tuition fees in the peri-urban areas repelled hopeful students, especially the economically poorer ones. What turned out to be more startling was even if the urban students had ample resources, it was distraction that was one of their major issues. Keeping these in mind, we propose the following solutions:

- The government should increase the production of gadgets like smartphones and laptops by providing incentives to companies and start-ups in this area of manufacturing so that their prices get low enough to be affordable by the peri-urban

students. Even the taxes associated with these items can be waived and discounts can be given to students residing in peri-urban areas and with low family annual income.

- The internet facilities should branch off as widely as possible so that no nook and corner is left out, especially the peri-urban and rural areas.
- A major concern in the peri-urban areas was lack of funds to afford private tutors and coaching centres. This is a recently emerging issue, so relevant to be addressed now or things will go out of hand. It is seen that a lot of tutors charge exceedingly high tuition fees even in rural areas. What's shocking is that these teachers are their school teachers themselves who teach carelessly in the schools but properly in the tuition classes. Since most of the students from poor families can't afford these, they fail to get any proper education even from their school teachers. This is a violation of human rights; hence stringent action should be taken at the earliest.
- Next, we see that quite surprisingly, distraction has affected a lot of urban students. To tackle this, their guardians have to be more cautious and stricter. It is often seen that students, during online classes, change tabs to things like YouTube, video games, social networking sites etc., and hence miss out on what is being taught. There is still another issue of short attention span in online mode. This can be handled if the teachers teach more effectively, particularly in a fashion where students find classes more interesting than anything else.
- To facilitate this, proper training of teachers should be done. This should be a government-sponsored event and should be implemented properly especially in the peri-urban and rural areas.

Limitations and ethical consideration

The major limitations were as follows:

- Only one district was the part of the research. It is possible that including other districts may invite drastic changes in the analysed results.
- There wasn't any representation of the rural population. Including them in future research can very possibly change the results obtained.
- The questionnaire was the only instrumentation in this research. Further analysis of specific points of the questionnaire could be done by interviews and re-designing the questionnaire properly.

- For the research in Odisha, some factors had very low expected cell counts in their associated contingency tables. So, none of the statistical methods used earlier could be used in them. This caused poor analysis of these particular factors. Also, increasing sample size might have helped in this matter.

Research ethics were upheld at all stages of the study. First of all, permission from the district education office in the Zambian case and of school heads in the case of Odisha was sought and granted. In both research studies, before distributing the questionnaires to the students, the headteacher or deputy headteacher for each participating school had to provide advice on the appropriate time to engage with selected students, while adhering to COVID-19 preventive measures. Before distributing the questionnaires to the students, the purpose of the study was explained to them and they were free to participate or not. In case of the google forms in the urban area, it was kept completely anonymous. Besides that, no name of schools, or name of a respondent has been disclosed in any publication except for the name of the district/city where the research was conducted.

Conclusion

Zambia:

One of the key findings of this study is that although peri-urban students experienced more difficulties in accessing remote learning during the COVID-19 school closure, urban students equally experienced some challenges including lack of access to ICT services, irregular supply of electricity, and lack of motivation to learn without physical interaction with the teacher and fellow students and due to their lack of self-confidence.

Odisha:

It was observed that poverty, which is highly prevalent in the peri-urban areas cut off student's access to coaching centres and private tutors. So, they relied on self-study and televised lessons. Lack of gadgets and poor internet connectivity affected the peri-urban students more than the urban ones; however, the result wasn't statistically significant, except when analysed with income levels instead of geographical locations. In the urban case, distraction in online mode dominated everything.

A parallel comparison shows that the problems in Odisha were new and differently associated, mostly because of Zambia lagging behind in its basic developmental goals.

All these call for effective actions both by the government and the guardians and school teachers of the respective places, as explained by us in the solutions.

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