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Regular Article

Student learning time analysis during COVID-19 using linear programming - Simplex method

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ABSTRACT

Covid-19 has made a significant impact on the lives of people. The education sector is also impacted by it. The unwarranted change was difficult to handle at first, but slowly got mitigated. The schools and colleges closed to avoid mass gatherings and communication. To help the education system cope with this virus, there was a need to understand how students would accept the change and what could be the impact of students' learning approaches due to Covid-19. This research focuses on examining students' learning habits during the pandemic. A dataset was constructed to examine Indian (Maharashtra) Students' learning habits during the time schools, and colleges were suspended due to the novel coronavirus- SARS-CoV-2 (COVID-19). In response to understanding the potential effects of the coronavirus pandemic, the questionnaires were spread over a network of educational communities on Facebook and Whatsapp from September 30 to October 20, 2020. Researchers delivered the given survey to teachers and parents to collect information. In order to live the influence of students' socio-economic status and occupational aspirations on their learning habits of students during school closures, the survey included three significant information concerns: (A) Individual demographics, including family socio-economic status(B) Student's learning time spent during COVID-19, Support system as teachers and parents guidance; and (C) Importance of Self-learning and Effectiveness of it. But this research focuses on the Student's learning time spent during COVID-19. Around 859 responses were received through the survey. With the effective aid of the LP model and the Simplex method, the importance of instructors during online learning can be analyzed. This paper presents results with the applied approach.

1. Introduction

1.1. Motivation and need

During the pandemic situation that happened because of COVID′19, all things changed suddenly and transition was observed mostly across all the sectors at the societal level, institutional level and also at individual level. Most of the education sectors are transformed from traditional teaching and learning methodology into online teaching. With regards to this, most of the institutions have started to put up their efforts to have an effective online teaching and learning process. With respect to this, institutions have arranged training programs for the teacher community to train them about the conduction of online classes effectively, use of different technologies like Google Classroom, OBS, Youtube channels, etc. to reach out to the students during pandemic situations. During such training programs, some of the tools for conducting the quizzes, game activities and taking the poll like Hot Potato, Moodle Quizzes and poll everywhere are also introduced to the teacher's community to engage the students during online learning. Some of the researchers also proposed a framework with required ICT tools and other necessary factors to make a good online learning process Md. Shahadat Hossain Khan [2021]. The impact of all such activities gives benefits in engaging the students and 70% of students are preferred online learning and they have engaged themselves Muthuprasad [2021]. It is also possible to run online classes like offline classes during such critical pandemic situations.

The online teaching and learning process goes day by day. It is also observed that, it is not possible for all students to attend the online

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classes and interact with instructors for the entire day. This situation is raised because of unavailability of internet connection continuously, computer machines are not there, facing problems to attend the online classes because of mobile device issues. In such cases, some of the students prefer self-learning without an instructor whenever the recorded learning data will be available for them. In such cases, one pinpoint has come into picture that, it is also necessary to identify the impact of online learning with instructor and without instructor. Afterwards, it is also required to identify the feasible amount of time students will spend during online learning as per the availability of required resources. This study is important and necessary because during the offline teaching learning process, it is always possible for students to communicate with teachers and it is possible for teachers to identify the engagement of students through different learning factors.

During COVID′19, a sudden change happened in the education section and it is necessary for faculties and students community to adapt themselves with the online learning transition phase. With respect to this, it is a major part to investigate the impact of students' socioeconomic conditions and it motivates to understand the impact of students' learning habits during a pandemic. So, to make study and analysis with this motivation, the researchers have conducted surveys through which, the online questionnaires circulated among student communities. The study asked three types of questions for the purpose of investigating the impact of students' socioeconomic condition and career objectives on the educational life while closing higher education institutions: (1) Personal characteristics, such as family socioeconomic status (2) Learning time spent by students during COVID′19 with instructor and without instructor, support system such as advice from teachers and parents, and infrastructure availability, and (3) The importance and effectiveness of self-learning.

The survey was conducted online and a questionnaire was circulated through WhatsApp and Facebook groups. There were a total of 866 entries on the form provided, in which 859 responses were considered for analysis. In the final dataset, there were 859 valid observations included and taken for further statistical analysis of student learning behavior during COVID′19.

1.2. Objectives

The main objective of this paper is to understand the student learning habits during pandemic. It has considered two situations: learning time given by students with instructors during online mode and offline mode. Similarly it also gives insights on learning time spent by students without instructor during online and offline mode.

1.3. Importance of data

This data set is broadly divided into three sections, Per-sonal information of students which includes demographic information, parental status and support system like siblings, teachers, parents, friends. It also focuses on time spent on learning per day during pandemic. This dataset has infor-mation of Engineering students from India, It can be used to conduct comparative study on students learning approaches during pandemic of different countries. It can also enhance the teaching learning process of engineering institutes by understanding changes in students' learning approaches and behavior. Institutes can be well prepared to handle such situations in future.

2. Literature review

Late in 2019, the SARS-CoV-2 coronavirus appeared in Wuhan, China. In the month of January 2020, very first deaths were reported in late January, and many countries had confirmed cases by late February and The World Health Organization has announced a worldwide health crisis as a result of this. Several countries advised or enforced self-containment at home and a nonverbal communication for at least 2 m is necessary, because the virus is highly contagious even among persons who show zero indications (six feet). Most firms have been obliged to close because of government policy or recommendations because no vaccination could be ready for several months Chen et al., [2020].

Higher education professionals have to rearrange training in as little as a few days to transition lectures from in-person to virtual or any other distant learning modalities Gardner [2020]. When students were taken away from their accustomed on-campus environs, it was difficult for them to adjust, they were perplexed, higher costs, worry, social isolation's consequences, as well as sleep difficulties Cao et al., [2020], Moukaddam and Shah [2020], Windes and Lesht [2014].

The work is also done to identify the student's perfection and preferences towards online learning and results show that 70% of students are interested in online learning. In this work, the effectiveness of online learning is not measured with respect to the number of hours students will spend and how much it is with teachers. T. Muthuprasad et al., [2021].

During the COVID′19, as all the institutions were closed suddenly, most of the teacher's community from developing countries like Bangladesh proposed a framework for conducting the flipped mode online classes and results showed that it is required for teachers to spend more time in designing effective classes. This work also shows that it is necessary to design and apply proper strategies about required learning time, effectiveness of online learning with teachers. Etc. Md. Shahadat Hossain Khan et al., [2021]

At home, many limited and overseas students lacked access to computers and the internet and because of this, the higher education institutions were in a hurry to identify the solution for online learning along with different factors with respect to use of ICT tools, availability of tools and technology Tang et al., [2021].

Many students who depend substantially on school resources such as food, housing, and healthcare realized they were without a "residence" to travel when their campus was closed Windes and Lesht [2014]. As a result, schools had to become more creative.

According to a poll conducted by the Kaiser Family Foundation in April 2020 Polyakova et al., [2021], The epidemic had an influence on 45 percent of Americans' mental health, with 19 percent indicating it had a "significant footprint". According to a different Kaiser Family Foundation survey Neary [2021], the coronavirus was said to have harmed the mental health of 58 percent of 18–24- year-olds in the United States.

Higher education soon recognized the importance of social bonds, as well as the social-emotional pain created by the pandemic school closures. In the paper Ruffolo et al., [2021] they claimed that treating student pressure by unreliability and quarantine, rather than just fine-tuning the practicalities of making instruction work, was at the heart of the issue of remote schooling. "Remain in contact with colleagues, make yourself available to students, and help the student make themselves accessible to one another" she advised. (p. 14).

Parents are motivated to bring their children to college or university for at least three reasons, according to Lieber [2020]: (1) accumulating knowledge and building better brains of adults, (2) acquiring a degree that conveys to potential employers your tenacity and ability to achieve, and (3) forming life-long friendships and mentors, both of which are difficult to accomplish when educating from residence. Numerous students were looking forward to returning to campus. "For me, sharing a facial interaction and communication in a classroom situation are both advantageous" a student of one of the writers remarked. I had no idea how often I took human connection on campus for granted till now but, and how much I cherish everything which happened." Students were disengaging, according to educators on discussion boards, causing teachers to struggle to keep their kids motivated Tang et al., [2021].

When a learner's learning environment is stimulating, they become more engaged and it encourages social and emotional development, fosters relationships, and employs effective instructional strategies. As a result, engaged students display behavior, Thought processes or feelings

that demonstrate a connection to the course topics, the teacher, and other students Greenhow et al., [2021]. Planning and solving a Product-Based Linear Programming Model Combine Linear and n Product Problems Tavana et al., [2021].

3. Methodology for data collection

The survey was conducted between September 30 and October 20, 2020, after the second month of nationwide online academic opening due to COVID-19. Initially, Old timers and instructors who were engaged in several edu-cational forums on Facebook were sent online surveys. A total of 866 feedback collected, but only 859 valid state-ments were used for further processing, here the independent variable is gender (total students). Other dependent variable relations are observed through regression analysis. Student's time given for online learning and offline learning during less than 4 h, period given within 4–7 h and period given for more than 7 h. In both cases periods spent with instructor and without instructor also taken care. It also gives observations related to student's time spent on learning before COVID 19. Fig. 1 shows data collection methodol-ogy. With the collected data through survey, Learning time details of students are shown in Table 1. It has information about time spent by students for online learning with instruc-tor and without instructor. Also it gives information about time spent by students for offline learning with instructor and without instructor. Survey has been conducted for 859 students. detailed information regarding duration in hours for learning is available in Table 1.

Table 1
Data collection.

Learning Time of Students (before Covid/During Covid/Online/Offline)	Duration in hours	No of Students
Learning time before COVID-19	>4 h	581
	4–7 h	249
	<7 h	28
TOTAL Learning time online during COVID-19	>4 h	142
	4–7 h	558
	<7 h	106
Learning time online with the instructor during COVID-19	less than 4 h	214
	4–7 h	589
	<7 h	55
ONLINE Learning time without instructor during COVID-19	less than 4 h	616
	4–7 h	209
	above 7 h	33
OFFLINE Learning time with the instructor during COVID-19	less than 4 h	666
	4–7 h	160
	above 7 h	32

4. Experimental design, materials, and methods

4.1. LP model and simplex method

To provide the optimal solution, the LP model is used and solved using either geometrically or using simplex method. To provide solutions to complex real life prob-lems which consist of more than two decision variables, the simplex method is used, otherwise the problems are also solved geometrically using the graphical method. The term Simplex is an important term in mathematics that is used to represent an object in n - dimensional space containing n+1 points. Even though the workable solution involves the optimal solution in the n-dimensional polyhedron region of the workable solution, it is not possible to graph the workable region for the LP problem with many variables. So to overcome this limitations, the simplex method is used because a simplex is a line segment connecting two points in one dimension and it forms a triangle if three point are there in three dimensions and it is used to examine by repeating the same set of stages of the algorithm for a

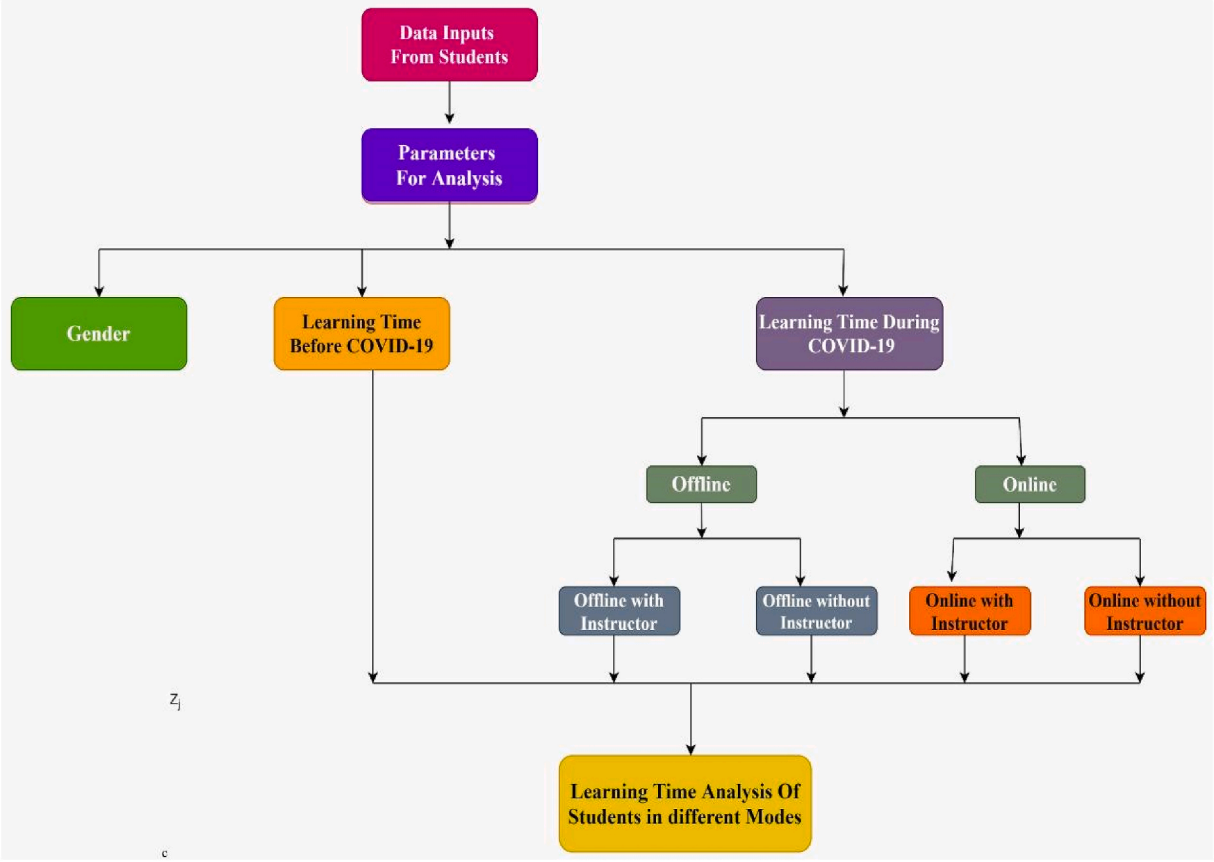

Fig. 1. Data collection methodology.

limited amount of incidents until the best answer is discovered, extreme points can be found systematically. So, this method is also called an iterative method. There are some basic assumptions of Linear Programming Model. It can be represented as com-ponents of linear programming model. They are identified as proportionality, additive,non-negativity,linearity, single or one objective function, certainty or deterministic. They are explained as given below, • Proportionality: Activity is relative to the quantity of resources contributed as well as used. • Additivity: Consumption and contribution are becom-ing increasingly important. • Non-negativity: The operations value cannot be nega-tive. • Linearity: Each product's productivity and the total quantity of each resource used have interaction effects. • Single or One-aim Function: There should only be one purpose in a problem: time to deal with or budget minimization, not both. • Certainty or Deterministic: For something to work, all values and quantities must be known. • External elements that aren't expected to change: This signifies that the external environment isn't likely to change. The following are the basic components of a Linear Pro-gramming model. The many components that make up an LP model are listed below. Linear programming is commonly described as inequalities. • Decision variables • Constraints/ limitations • Non – negativity constraint • Objective function.

4.2. Formulation LP model

LP model formulation has two important phases, first phase to understand parameters in linear programming prob-lem. Second phase to follow various steps to formulate LP model.

4.2.1. Identification of parameters in a linear programming problem

1. Parameter 1: Decision variables are mathematical symbols that describe an operation's level of activity.
2. Parameter 2: An objective function is a linear mathematical relationship that expresses a problem's goal in terms of a decision variable, which can be maximized or minimized.
3. Parameter3: Constraints, which are limitations imposed on the problem.
4. Parameter4: The numerical coefficients and constants employed in the objective function and constraints equations are known as parameters/cost coefficients.

4.2.2. Linear programming model formulation steps

Linear programming problems include the objective function, a set of conditions, and a set of non-negative regulations. As a result, we'll look at the steps that go into solving a math issue. 1. Define exactly the problem's decision variables. 2. As a linear combination of the decision variable, write the goal function. 3. Formalize the drawback constraints as a joint distribu-tion of the decision variables.

4.3. Linear programming solution using simplex method

The Simplex method is a set of mathematical procedures for solving a linear programming problem in a simplex tableau, which is a table. The tableau arranges the model in a way that makes it easy to apply the mathematical processes. The Simplex method is an algebraic iterative method that progresses in finite steps from initial basic viable solutions to the optimal basic feasible answer. The objective function and restrictions must be standardized in order to develop solutions for the linear programming issue using the Simplex approach. The characteristics of the standard form are: – Except for non-negativity constraints, which must be represented as inequalities, all constraints must be expressed as equations. The tableau format can be used to solve the linear programming problem using the Simplex approach. The right-hand side of each constraint equation must be non-negative.

Linear Programming is a mathematical technique for finding the best or optimal solution for a given objective function. It may be defined as a method of optimizing (i.e maximizing or minimizing) a linear function for several constraints stated in the form of linear equations.

The standard mathematical model to optimize a function $Z = f(X)$ *as given in Eq. (1).*

Optimize Z (either maximize or minimize)

$$Z = C_1X_1 + C_2X_2 + C_3X_3 + \ldots + C_nX_n \quad (1)$$

Subject to linear constraints

$$a_{11}\, x_{11+} \cdots + a_{1n}x_{1n} + S_1 = b_1 \vdots \ddots \vdots a_{m1}x_1 + \cdots + a_{mn}x_n + S_m = b_m$$

In the simplex method, three types of additional variables are used,

Type 1: Slack variables demoted as S which are used to represent unused variables either in the form of resources used to optimize the given function.
Type 2: Surplus variables are indicated by the letter (-S) and are used to describe the amount by which a resource's solution value expresses it. These variables are also known as negative slack variables and, like slack variables in the objective function, have a zero coefficient.
Type 3Artificial variables, denoted as (A) - These variables are used to generate an initial solution to the LP problem.

The above variables are added to LP problem for the following reasons:

a) To convert the given LP problem into a form that is amenable to algebraic solutions, so these variables allow to convert inequalities into inequalities.
b) These variables make it possible to make a better comprehensive economic representation of the final solution.
c) Help to get an initial feasible solution represented by the columns of the identity matrix. When the LP problem is solved to maximize the optimization function Z, then slack variables are used and when it is solved to minimize the optimization function then surplus and artificial variables are used as per the steps given in the algorithm of the LP Simplex method. LP model standard process is shown in Fig. 2 and Table 2.

4.4. Flow of LP model

Fig. 2, shows the flow of the LP model. It uses variables and forms an initial simplex table. The initial simplex table will calculate the value of Zj, Cj - Zj. In the case of the maximization problem, the positive difference of Cj - Zj will be considered to go to the next step. In the case of minimization, the negative difference of Cj - Zj will be considered. It follows the interaction of the simplex method. In each iteration, if the value of Cj - Zj is less than or equal to zero i. e (Cj - Zj $\leq$ 0), the current solution will be taken as the final optimum solution otherwise the same model is iterated with newly calculated row values.

5. Implementation and results

5.1. Use case of student learning time analysis using simplex LP model

The LP model consists of the following steps to analyze the learning time of the students in online mode with an instructor and without an instructor.

Step 1: Use of Decision Variables, Constraints and Optimization Functions

As shown in Table 3, As per the dataset this step focuses on two types of learning activities. First learning with an instructor and then learning without an instructor.

Assumptions:

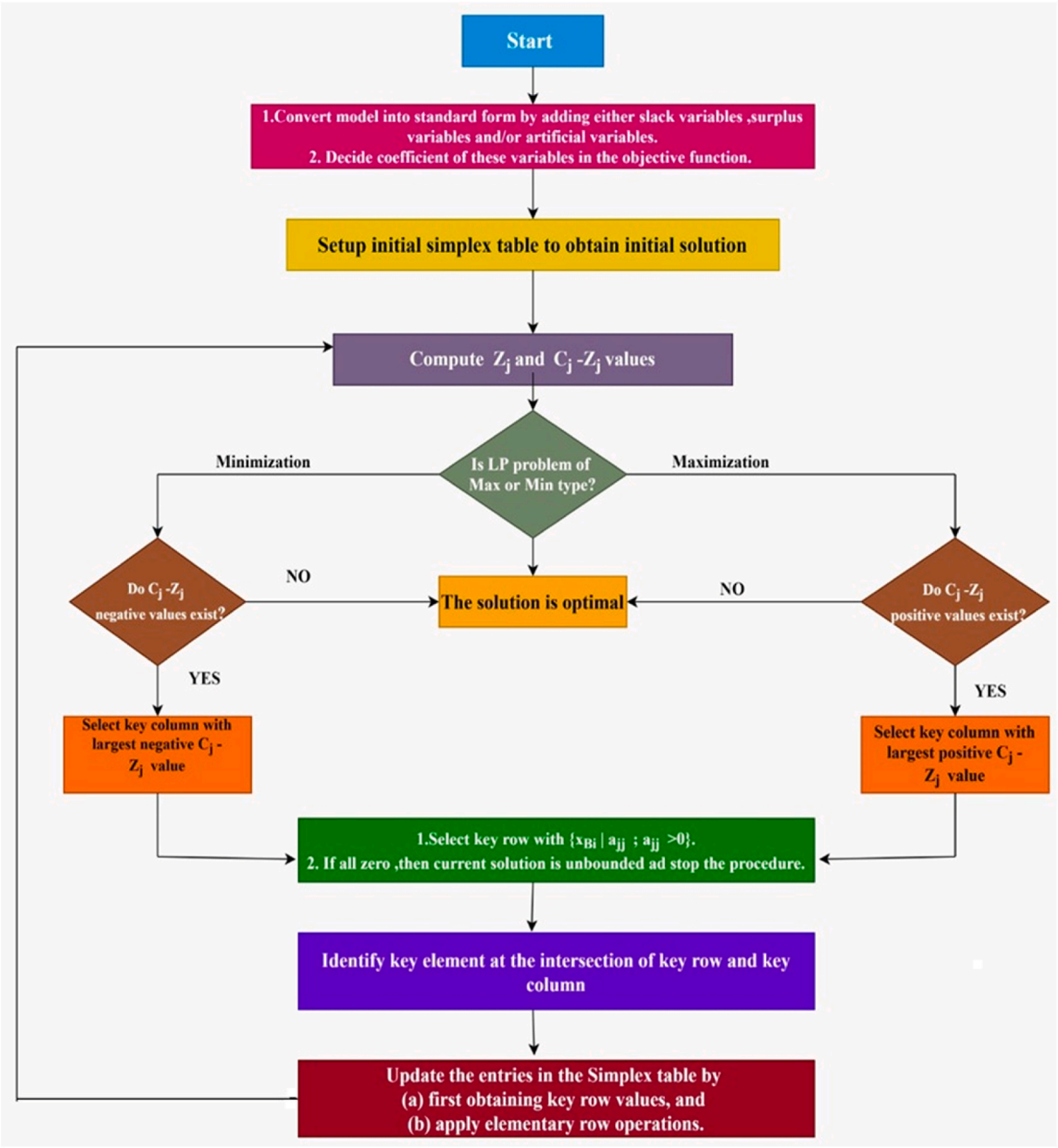

Fig. 2. LP model flow.

Table 2
Standard form of LP Model - Simplex Method.

Type of constraint	Extra Variable Required	Coefficients of Extra Variables in the objective function		Presence of Extra Variables in the initial solution
		Max - Z	Min - Z	
≤	Slack Variable is added.	0	0	Yes
≥	Surplus variable is subtracted	0	0	No
	Artificial variable is added	-M	+M	Yes
=	Only artificial variable is added	-M	+M	Yes

Table 3
Learning time of students.

Learning Time of Students (before Covid/During Covid/Online/Offline)	Duration in hours	No of Students
ONLINE Learning time with the instructor during COVID-19	less than 4 h	214
	4–7 h	589
	<7 h	55
ONLINE Learning time **without** instructor during COVID-19	less than 4 h	616
	4–7 h	209
	above 7 h	33

Before the covid situation, it is assumed that a student spent 3 h with an instructor, 5 h without an instructor.

Decision variables:

X1 is the learning activity with instructor X2 is the learning activity

without instructor.

Constraints:

Learning time for students has three dif-ferent constraints, Constraint1: Learning time is less than 4 Hrs. Constraint2: Learning time from 4 to 7 Hrs. (consider average time = 5.5 Hrs.) Constraint3: Learning time is more than 7 Hrs.

Optimization Function:

Therefore, the LP Model to maximize the optimization function Z to assess the learning activity with an instructor and without an instructor is as follows:

$$\text{Maximize } Z = 3X_1 + 5X_2 \tag{2}$$

Subject to following constraints

$214X1 + 616X2 \leq 4$

$589X1 + 209X2 \leq 5.5$

$55X1 + 33X2 \leq 7$

Where X1, X2 > 0.

The summarization of the data to form the LP model is given in Table 4.

To optimize the function of learning activity, it is necessary to introduce three non-negative slack variables S_1, S_2 and S_3 variables. Add them to convert to non-equality to equality constraints, shown in eq (3).

$$Z = 3X_1 + 5X_2 + 0S_1 + 0S_2 + 0S_3 \tag{3}$$

Subject to the following constraints

$$214X_1 + 616X_2 + S_1 = 4 \tag{4}$$

$$589X_1 + 209X_2 + S_2 = 5.5 \tag{5}$$

$$55X_1 + 33X_2 + S_3 = 7 \tag{6}$$

Where $X_1, X_2, S_1, S_2, S_3 \geq 0$.

Step 2: Formation of Initial Simplex Table

Initial simplex table consists of information for the equa-tions 3, 4, 5 and 6 framed in step 1. This information is shown in Table 5. It has S1, S2, S3 as the basis variables and X1, X2 and non basis variables. The first row of Table 5 indicates the coefficients Cj of variables in the objective function specified in eq. no. 3 and these values will remain the same in successive tables in the next step of iteration. The values of b are taken as the right side values of equations (5)–(7).

Where Z = value of optimize function, j = 1, 2, 3,4,5.

$$Zj = C_{Bi}X_j = \sum (\text{B.V.coefficients})\text{X}(\text{j}^{\text{th}} \text{ column of data matrix}) \tag{7}$$

Step 3: Calculation of Zj and $C_j - Z_j$

As shown in Table 6, the values of $C_j - Z_j$ are 3, 5, 0, 0, 0 and this shows that, $C_j - Z_j \geq 0$, So the simplex model can go for iteration 2 to find the optimal solution.

To proceed for iteration 1, consider the maximum of $C_j - Z_j$ (3, 5, 0, 0, 0) which equals to 5 and it belongs to non-basic variable X_2. So, the column having X_2 is declared as a key column which is shown in yellow colour. The variable X_2 becomes the incoming variable in iteration 1.

The minimum value of Min Ratio =(XB/X2) is computed to find out the key row and R1 represents the minimum value shown in blue colour which is declared as the key row. The variable S_1 is the outgoing variable in iteration 1.

The intersection value of the key column and key row is 616 which is the key element and in the next iteration, the row operations are performed with respect to this.

Step 4: Iteration Number 1.

To get an improved solution shown in Table 7, this step focuses on making the key element found in step 3 equal to 1. In this use case the key element is x2 = 616 and other values of the key column are made to "0". The other elementary row operations are performed with respect to the key row.

To proceed for iteration 2, consider the maximum of $C_j - Z_j$ (1.262987013, 0, −0.00811688,0, 0) which equals to 1.262987013 and it belongs to non basic variable X_1. So, the column having X_1 is declared as a key column which is shown in yellow colour and it becomes the incoming variable in iteration 2.

The minimum value of Min Ratio =(XB/X1) is computed to find out the key row and R2 represents the minimum value shown in blue colour which is declared as the key row. The variable S_2 is the outgoing variable in iteration.

As shown in Table 7, the values of $C_j - Z_j$ (1.262987013, 0, −0.00811688,0, 0) are not equal to zero, so there is further scope for improvement.

The intersection value of the key column and key row is 588.653 which is the key element and in the next iteration, the row operations are performed with respect to this.

To get an improved solution shown in Table 8, this step focuses on making the key element found in step 3 equal to 1. In this use case, the key element is X_1 = 588.653 and other values of the key column are made to "0". The other elementary row operations are performed with respect to the key row.

Step 5: Iteration Number 2

After completion of Iteration Number 1, it is observed that, X_1 is an incoming variable and basis variable S_2 is an outgoing variable. These variables are used to iterate the simplex algorithm by performing the necessary key elementary row operations. This operation is performed to make the value of key column X1 = 588.653 to "1" and other values of a key column to "0". The result of iteration number 3 is shown in Table 8.

It is observed that, the values of $C_j - Z_j$ are equal to zero for X1, X2 and S1, S2 variables which indicates that, condition $(C_j - Z_j \leq 0)$ is satisfied in iteration number 2 only. There is no need to iterate the linear model again and the feasible solution of iteration number 2 becomes the optimal solution. Hence, this use case has got the optimal solution in iteration number 2 as per the flow shown in Fig. 1.

5.2. Analysis of student learning use case with simplex method

This section focuses on two types of analysis of students learning use case with the simplex method. Result analysis part I, as shown in Fig. 3 gives insights of students learning with instructor and without instructor. With the LP Model, the result of X1and X2 decision variables are 0.009332341, 0.006432907. These values show that the learning time spent with instructors is better than the learning time spent without instructors. The result analysis shown in Table 9 and Fig. 4 indicates that, as learning time goes on increasing from 4 Hrs. to 7 Hrs. Either with instructor or without instructor, the maximum number of students are comfortable with instructor and preferred 5.5 Hrs. of online learning time.

Table 4
Summarization of data to form the LP Model.

Resource		Online Learning Activity	
Learning Time	Constraint	With Instructor (X_1)	Without Instructor (X_2)
Less than 4 Hrs.	4 Hrs	214	616
4 to 7 Hrs.	5.5 Hrs	589	209
More than 7 Hrs.	7 Hrs	55	33

Table 5
Formation of initial simplex Table.

C_j		3	5	0		0	0	b
Time Constraints (CB)	Variables in Basis (B)	X1	X2	S1		S2	S3	
0	S1	214	616	1		0	0	4
0	S2	589	209	0		1	0	5.5
0	S3	55	33	0		0	1	7
$Z=\sum C_{Bi} X_{Bi}$	$Z_j=\sum C_{Bi} X_j$	Z1	Z2	Z3	Z4	Z5		
$C_j - Z_j$								

Table 6
Extended simplex table with initial values.

			3	5	0	0	0	B (= X_B)	Min Ratio (XB/X2)
R. No.	Time Constraints (C_j)	Variables in Basic (B)	P_1	P_2	P_1	P_2	P_3		
R1	0	P_1	214	616 Key Element	1	0	0	4	0.006494 Key Row
R2	0	P_2	589	209	0	1	0	5.5	0.026316
R3	0	P_3	55	33	0	0	1	7	4.714286
R4			P_1	P_2	P_3	P_4	P_5		
R5	$=\sum$	$=\sum$	0	0	0	0	0		
R6	$C_j - C_j$		3	5	0	0	0		
				Key Column					

5.3. Analysis of student learning use case with heatmap

Another way to do analysis of student learning habits during COVID19 is Heat MAp analysis. In this method heat map analysis is given for student learning time before and during the COVID 19. Before COVID 19, it depicts that important factors like maintaining learning habits, family and teachers support and motivation of self learning had a negative correlation indicating no contribution in boys student progress which can be concluded from heat mapping in Fig. 5. Heat map Analysis in Fig. 6 of Boys During COVID 19, as compared to Fig. 5 this analysis shows positive correlation with the discussed factors and provides us better insights in dealing with student's learning progress. The results indicate that student time is spent in other activities and there is a lack of time and motivation for studies. As shown in Fig. 7, Heat map Analysis for Girls: Before COVID 19, depicts that important factors like maintaining learning habits, family and teachers support and motivation of self learning had a negative correlation indicating no contribution in student progress. As shown in Fig. 8, Heat map Analysis of Girls During COVID 19, as compared to Fig, 7 this analysis shows positive correlation with the discussed factors and provides us better insights in dealing with students' learning progress.

Table 7
Simplex Method with improved solution in iteration1.

			3	5	0	0	0		
R. No.	Time Constraints (C_B)	**Variables in Basis (B)**	X_1	X_2	S_1	S_2	S_3	**B (= X_B)**	**Min Ratio (XB/X2)**
R1	5	S_2	0.347403	1	0.001623	0	0	0.006493506	0.018691589
R2	0	S_2	**588.653 Key Element**	0	-0.00162	1	0	5.493506494	0.009332341 **Key Row**
R3	0	S_3	54.6526	0	-0.00162	0	1	6.993506494	0.12796293
R4			X_1	X_2	S_3	S_4	S_5		
R5			1.737012987	5	0.008116883	0	0		
R6	$C_B - C_B$		1.262987013	0	-0.008116883	0	0		
			Key Column						

Table 8
Simplex Method with improved solution in Iteration 2.

			3	5	0	0	0	
R. No.	**Time Constraints (C_B)**	**Variables in Basis (B)**	X_1	X_2	S_1	S_2	S_3	**B (= X_B)**
R1	5	S_2	0	1	0.0016234	0	0	**0.006432907**
R2	3	X_1	0.99996	0	-2.75778E-06	0.001698	0	**0.009332341**
R3	0	S_3	0	0	-0.001623381	0	1	0.032164534
R4			X_1	X_2	S_3	S_4	S_5	
R5			3	5	0	0	0	
R6	$C_B - C_B$		0	0	0	0	0	

6. Conclusion

As the objective is defined to identify the learning time effectiveness in two situations such as 1) with instructor and 2) without instructor, and it is investigated that, learning analysis with instructor became more weighted as compared with learning analysis without instructor. To

Table 9
Result analysis - II.

Resource		Online Learning Activity	
Learning Time	Constraint	With Instructor (X_1)	Without Instructor (X_2)
Less than 4 Hrs.	4 Hrs	199.7120874	396.2670638
4 to 7 Hrs.	5.5 Hrs.	549.6748573	134.4477538
More than 7 Hrs.	7 Hrs.is	51.32787292	21.2285927

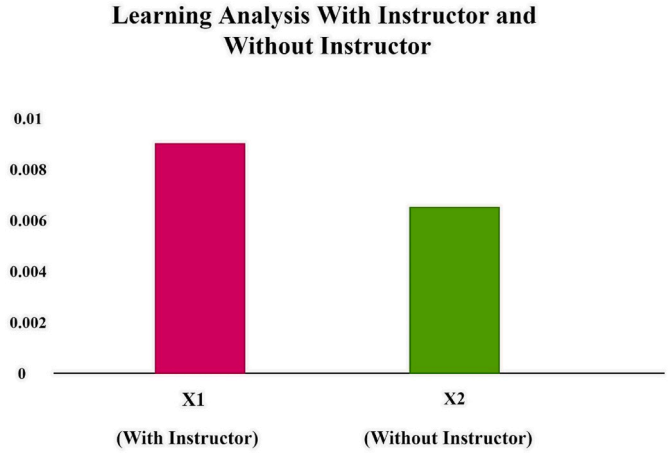

Fig. 3. Result analysis part – I.

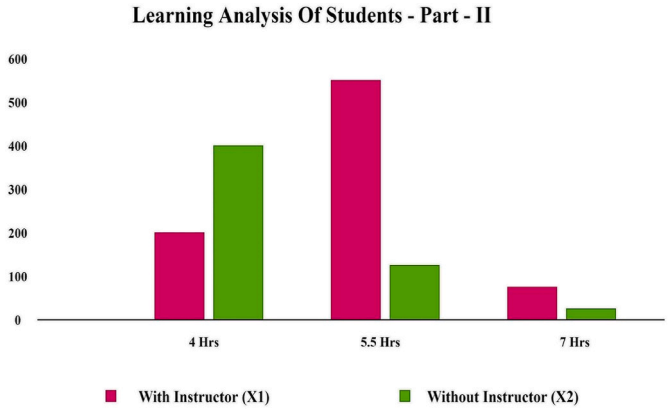

Fig. 4. Result analysis part - II.

make such investigations, most of the time weighted graphs are used and analysis is done. In this paper, the simplex method of linear programming is used and it is observed that it is a proven scientific method to obtain the statistical learning analysis of the students during pandemic situations. The simplex algorithm specified that, the maximum number of students (550 students out of 859) that is 64% of students have preferred 5.5 h for online learning. The result of decision variables X_1 and X_2 are 0.009332341, 0.006432907 respectively which indicates that the learning analysis of the students with instructor (X_1) is always good as compared to the learning of analysis of students without instructor (X_2). Heat map analysis also gives positive correlation with the discussed factors and provides us better insights in dealing with student's earning progress.

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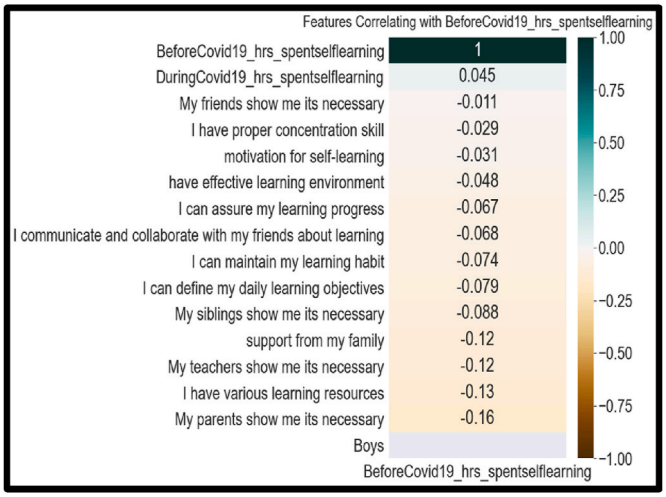

Fig. 5. Heat map Analysis for Boys:Before COVID 19.

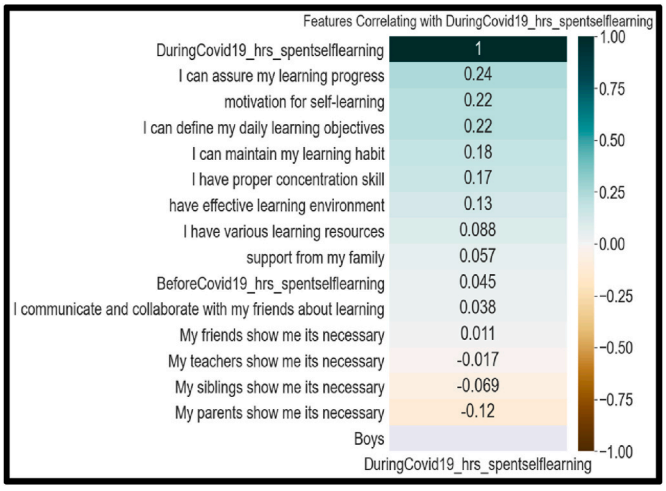

Fig. 6. Heat map Analysis of Boys During COVID 19.

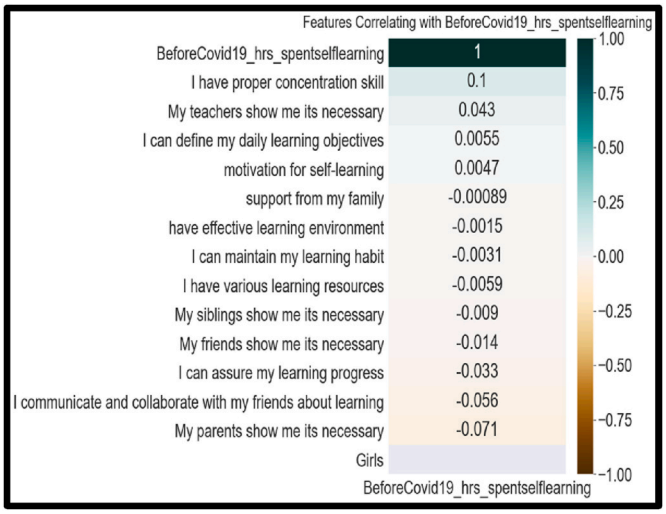

Fig. 7. Heat map Analysis for Girls: Before COVID 19.

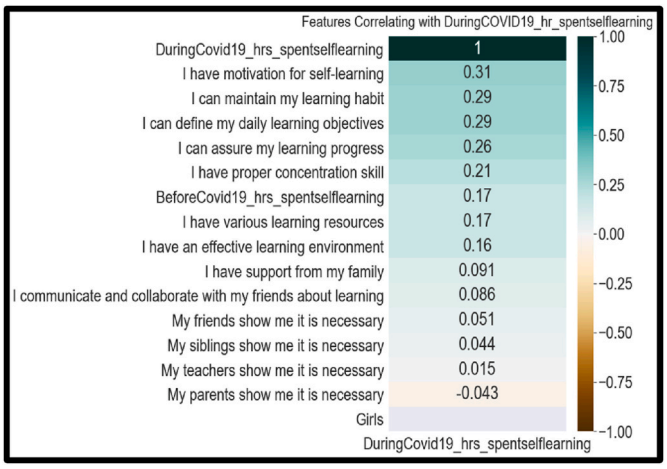

Fig. 8. Heat map Analysis of Girls During COVID 19.

Declarations of competing interest

None.

CRediT authorship contribution statement

Sujata Pardeshi: Investigation, Conceptualization, Methodology. **Sushopti Gawade:** Formal analysis, Modeling, Data creation, Analysis. **Palivela Hemant:** Conceptualization, and Data creation.

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