



Evaluating the impact of online learning during COVID-19 period using Data Mining Techniques

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Abstract- The rapid spread of COVID-19 has caused many countries, including Sri Lanka, to close all educational institutions and convert to online learning. However, this sudden shift has not been without its challenges. In this study, the authors aimed to identify the factors that affect online learning in Sri Lanka and determine how it has impacted university students' academic performance, CGPA, and perceptions during the pandemic. We used data mining and machine learning techniques to create prediction models based on a questionnaire distributed to university students. The results showed that prolonged use of digital devices and psychological factors such as stress, distraction, and loneliness had a negative impact on students' CGPAs, while a good internet connection had a positive correlation. The study also found that there was no significant difference in online lectures, but the online practicals showed a negative correlation. The authors suggest that the weak educational policies and the impact of the pandemic underscore the need for an interdisciplinary approach to strengthen the quality of online education in Sri Lanka. We urge education policymakers and the government to develop new strategies that ensure equity, equality, and unfettered access to education. Ultimately, the lessons learned from this pandemic must be used to build a sustainable online education system for future pandemics and the post-pandemic era.

Keywords: COVID-19, EDM (Educational Data Mining), Online learning, Undergraduate academic performance, Machine learning

I. INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 19 (COVID-19), is a highly contagious and pathogenic viral infection (Shereen et al., 2020). The pandemic caused by coronavirus disease (COVID-19), first reported in Wuhan, China, in December 2019, has spread rapidly around the globe, reaching more than 636 million confirmed cases worldwide by November 2022 (WHO, 2022). The World Health Organization (WHO) declared global pandemic status on March 11, 2020 (WHO, 2022), and by today, nearly 6.6 million deaths have been reported worldwide due to COVID-19 infection (WHO, 2022). In Sri Lanka, the first confirmed case of COVID-19 was reported in January 2020 (Amaratunga et al., 2020). In Sri Lanka, intermittent curfews had been imposed throughout the country. The first curfew was imposed on Friday, March 20, 2021, and lasted until Monday, March 23, 2021. When COVID-19 spread so widely in Sri Lanka, there were even periods when the country was under lockdown for more than three months. Between January 3, 2020, and November 29, 2022, more than 650,000 confirmed cases of COVID-19 and more than 16,000 deaths were reported. Currently, more than 40 million doses of vaccine have been administered in Sri Lanka (WHO, 2022).

In today's world, the rapid spread of the COVID-19 global pandemic is causing dramatic changes in many areas of the world, and education is no exception (Pócsová et al., 2021). It has serious implications for the traditional education systems followed by most developing countries (Xiao et al., 2021). The government of Sri Lanka is one of the countries that provides free education. A significant amount of money is allocated

from the government budget for regular education. Since the last COVID-19, the world education system has changed, and so has Sri Lanka. Given the rapid spread of the pandemic, governments in many countries, including Sri Lanka, have no choice but to close all educational institutions, from preschools to universities (Abdelkader et al., 2022; Xiao et al., 2021). This has a serious negative impact on students' academic education and leads to a ripple effect that can affect literacy and the country's economy. Some studies explain that this has a negative impact on the mental health and well-being of students, especially students who are exposed to extreme conditions in their academic lives (Mondragon-Estrada & Camacho-Zuniga, 2021).

Many educational institutions around the world have stated that they are looking for new educational methods to continue students' education without interruption during the pandemic period. This leads to a great demand for online teaching and learning platforms, and many educational institutions around the world are now offering their educational programs through these platforms. Moreover, this era has seen the development of many online computers and online-based platforms. Massive Open Online Courses (MOOCs), Student Information Systems (SIS), Intelligent Tutoring Systems (ITS), and Learning Management Systems (LMS) are a few examples (Bakhshinategh et al., 2018; Xiao et al., 2021). Among those, the most popular platforms for supplementing or enhancing e-learning offerings with a different learning experience are learning management systems (LMS) such as WebCT Vista, Blackboard, MOODLE, ATUTOR, and video conferencing technologies such as Zoom, MS Teams, and Google Classrooms (Subashini et al., 2022). Currently, many universities in the world use e-learning or learning management systems to continue their academic work (W. Nuankaew & Nuankaew, 2021; Tan & Lin, 2021). According to previous research, more than 90% of higher education institutions in Sri Lanka offer distance learning programs for their students currently.

Digital literacy means that students must adapt quickly to new learning methods, but not all students can adapt immediately to new technologies. According to Xiao et al., 2021 during the learning process at the university, every student completes basic studies in the first two years, and after they're clear about their strengths and preferences, they can easily continue their studies through any platform. The situation is quite different for freshmen, who have no idea about their field of study. Thus, online education has a negative impact on freshmen than in the traditional education system (Xiao et al., 2021). Also, Tan & Lin (2021) reported that this online learning has an impact not only on students but also on teachers. At every level of education, many

students and teachers suffer from low internet connectivity and the rapid requirement of expensive new devices and technology (Abdelkader et al., 2022; P. Nuankaew et al., 2021). These phenomena create a route to reconsidering the quality of online learning in terms of perfect learning outcomes. Moreover, reliable assessment is needed to ensure the overall quality of the learning outcome. In this context, the usage of data mining techniques and machine learning is readily visible (Mohd et al., 2021).

Nowadays, with the intensive use of learning management systems, data mining techniques are becoming more and more popular (Xiao et al., 2021) because almost all educational institutions want to improve the quality of their learning systems while improving the academic performance of their students (Abdelkader et al., 2022). According to Bakhshinategh et al. (2018), Educational Data Mining is a research area in education that addresses all educational stakeholders to discover qualities in education in an interdisciplinary setting while providing better guidelines for improving their roles in education. With the use of student database analysis, methodology development, and methods from the domains of statistics, machine learning, and data mining, Educational Data Mining (EDM) seeks to comprehend students better. This enables top management and education policymakers to decide more effectively how to improve education (Mohd et al., 2021). However, according to Xiao et al. (2021), conventional data mining methods are not suitable for immediate implementation in education due to their specialized purpose and function. This means that a pretreatment approach must be employed first, and only after that can particular data mining techniques be used to solve the issues. According to Tan and Lin (2021), the effectiveness of online learning systems can be influenced by data mining techniques such as decision rules, classification, grouping, sequence patterns, prediction, and trend analysis.

Moreover, many researchers around the world are trying to apply EDM to educational systems in different ways. According to Thakar et al. (2015), data mining techniques have been extensively used in education, although there are still many unexplored areas and no standard approach is being used. Ashraf et al. (2020) use the EDM technique to evaluate student exam papers. In this study, on comparing the boosting app, the Naïve Bayes algorithm, they integrated it with the J48 classifier and the synthetic minority oversampling technique. Also, in another study developed by Troussas et al. (2020), which is used to detect student activity interaction. In this study, using fuzzy logic, student traits were identified, and using fuzzy output based on decision-making approach refined important rules were analyzed. Gonzalez et al. (2020) found that there were significant

differences between students' academic performance before and after the COVID-19 pandemic. Student test scores were compared in 2020, and it was found that there were statistically significant differences in student performance throughout the year. A study conducted in Indonesia found that the COVID-19 pandemic had a negative impact on children's mental and psychological development. They found that almost all respondents were very anxious (Ardan et al., 2020). The present study predicts Sri Lankan undergraduates' academic performance using data mining techniques and exposes the factors affecting online learning while proposing new actions and recommendations to build a more qualitative and sustainable education system in Sri Lanka.

II. MATERIALS AND METHODS

A. Data collection strategy

The present study empirically determines the impact of online learning on undergraduate learning performance, targeting all levels of undergraduates in universities in Sri Lanka, both in the government and private sectors, under a four-step methodological cascade system (Figure 1). The study was conducted at universities accredited by the

University Grant Commission of Sri Lanka. Currently, there are 18 government and 24 private universities offering degree programs in Sri Lanka. Primary data were collected from January 2021 to March 2021 using a pre-tested online semi-structured questionnaire. The questionnaire was pre-tested with a small group of respondents ($n = 50$) at the Faculty of Technology, University of Ruhuna. The final questionnaire was improved and modified based on the experience from the pilot study. The final questionnaire consists of 32 questions in three sections focusing on the respondent (except the name), academic status, status of IT skills and availability of resources, connection status, student perceptions of online learning, physical and mental concerns, etc. The questionnaire was developed in both English and Sinhala to ensure tremendous respondent contact with the study. The first and second parts of the questionnaire consist of yes/no and multiple-choice questions, and in the last part, all responses were classified into an evaluation range according to a Likert scale that consists of five evaluation categories: strongly disagree (1), disagree (2), uncertain (3), agree (4), and strongly agree (5). Each evaluation category on the scale indicates the desired level of agreement for each question in the questionnaire. Participation in this survey was voluntary and anonymous. The data collected from participants was kept confidential.

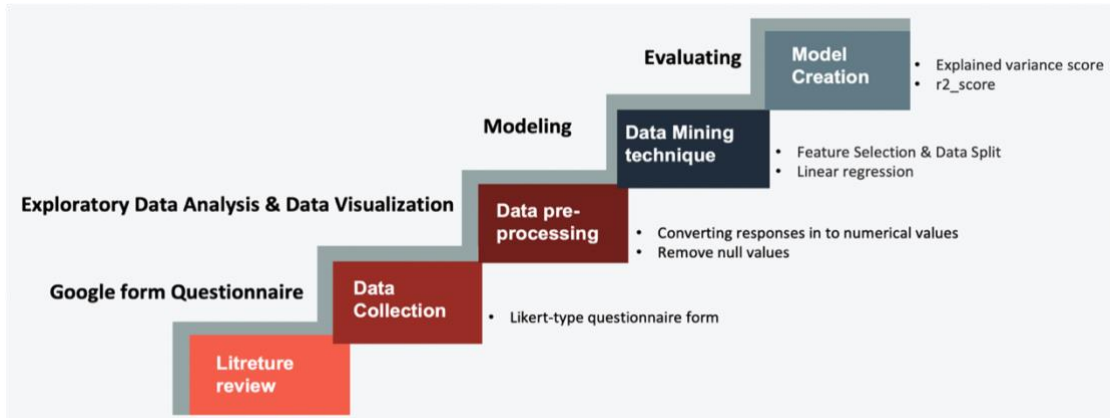


Figure 1. Followed four step methodological cascade system

B. Modeling and Data analysis

Collected qualitative and quantitative data such as status of the internet connection, student perception on online exam, number of hours spend for the learning before and after the pandemic, student perception on online theoretical and practical component and Status of mental conditions during the lectures, etc... from undergraduate students in Sri Lankan government and private universities was analyzed for the country as a whole, hereafter termed "Sri Lankan undergraduates." Collected data were converted to a machine-readable format with all null values removed, the data was visualized, and the prediction model was constructed using five data mining techniques: the ordinal least squares algorithm, Ridge regression, Lasso regression, Bayesian regression algorithm, and elastic net regression. The model was evaluated using evaluation metrics.

In this study, the data analysis was conducted using various Python packages (version 3.8) on the Google Colaboratory platform. These packages were utilized for data preprocessing, visualization, modelling, and evaluation. The primary package employed for data processing was Pandas, while NumPy was utilized for array manipulation. Matplotlib was employed for visualizing the data, and term color packages were used for customizing the text. The Google Colab and these packages were chosen for their ability to handle large amounts of data and to provide a cloud-based computing environment that is both efficient and easily accessible. By using these packages in conjunction with the Google Colab, the study was able to ensure the accuracy and reliability of the results obtained.

To begin the data preprocessing phase, all data records were stored in a.csv file, which was then uploaded into the development environment from Google Cloud. Data preprocessing involved removing all null values in the dataset using the "dropna" function and converting all the data to a machine-readable form. After removing the null values rest of the respondent selected to study. To transform data into a machine-readable form, label encoding was used to convert string data to numerical values. The "describe" function was used to obtain a statistical view of the dataset, which showed the count, mean, standard deviation, minimum value, maximum value, etc., in each column of the dataset. After the initial data preprocessing phase, the data was subjected to further

cleaning and preparation. This involved identifying and removing any outliers or anomalies in the data that may have skewed the results. The data was also normalized using the MinMaxScaler function to ensure that all variables were on the same scale, which is important for many machine learning algorithms. Any duplicate data was then removed to ensure that the analysis was not affected by redundancy. Finally, the data was split into training and testing sets using the

train_test_split function, with a split ratio of 80:20, respectively. This was necessary to evaluate the model's performance and to prevent over fitting of the model on the training data. Through these additional steps in data preprocessing, the machine learning algorithms were better able to accurately analyze the data to generate meaningful insights.

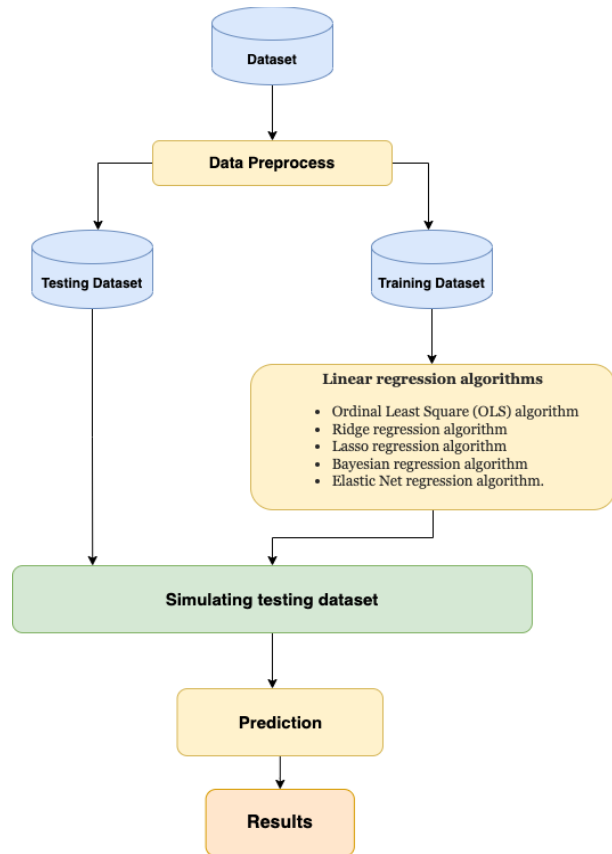


Figure 2. Diagrammatic view of the system architecture of the model

Once the data was preprocessed, the next step was to identify and label the independent and dependent variables. In this dataset, the dependent variable was the CGPA (cumulative grade point average), while all other variables were considered independent. As the final step in the data exploration and visualization part, it was important to check each variable's data type. This was necessary because linear regression performs well on integer type variables. Any float or object-type variables were converted into integer form to ensure the accuracy of the model. This was achieved by using the "astype" function in Pandas, which converted the data type of the selected column(s) to the specified data type. By performing this additional step, the data was better suited for linear regression analysis and produced more reliable results.

To develop the model, five linear regression algorithms were employed, including the Ordinal Least Square (OLS), Ridge regression, Lasso regression, Bayesian regression, and Elastic Net regression algorithms. Each algorithm was evaluated to determine its performance in predicting the CGPA.

Figure 2 presents a diagrammed view of the system architecture of the model, showing how the algorithms were integrated and the data was processed to generate predictions. The purpose of using multiple algorithms was to evaluate which algorithm performed best in predicting the dependent variable, thereby improving the accuracy of the model. In this section, we evaluate the performance of the different regression models used to predict the target variable. We used several evaluation metrics to assess the performance of the models, including the mean squared error (MSE), root mean squared error (RMSE), and coefficient of determination (R-squared). The results of the model development and evaluation will be discussed in detail in the Results section.

III. RESULTS

The study received a total of 750 responses to the Google form, with the majority of participants being students from the University of Ruhuna (50.8%) followed by University of Colombo (8.7%), the University of Peradeniya (9.0%). All the respondent studying universities is listed under Table 1.

Among the students of the University of Ruhuna the majority of participating students were from the Faculty of Technology (42.4%), followed by the Faculty of Arts (22.3%), the Faculty of Science (15.6%), the Faculty of Engineering and Management (8.5%), and the Faculty of Medicine (2.7%).

Of the respondents, 51.6% were male and 48.4% were female. In terms of academic level, 18.1% were first-year students, 28.7% were second-year students, 16% were third-year students, and 37.2% were fourth-year students. The IT skills of the participants were also assessed, with 35.6% reporting advanced IT skills, 54.8% reporting intermediate IT skills, 9% reporting basic IT skills, and 0.5% reporting novice IT skills.

Based on the findings of this study, it was revealed that prior to the outbreak of COVID-19, only a mere 39.4% of students had previous experience with online learning sessions, while a smaller percentage of 30.3% sometimes participated in online courses. Alarming, 30.3% of the participants had never experienced online learning sessions before the pandemic. These results indicate a relatively low level of exposure to and familiarity with online learning platforms among students prior to the COVID-19 pandemic.

A. Model Performance Evaluation

The performance of different regression models was evaluated based on the explained variance score and the r-squared score. Among the tested models, the Lasso regression model showed the highest accuracy in predicting the target variable.

Table 1. Percentage of participant from each university in Sri Lanka

University	Percentage amount of participant
University of Ruhuna	50.8
University of Colombo	8.7
University of Peradeniya	9.0
University of Sri Jayawardhanapura	5.3
University of Moratuwa	4.8
University of Jaffna	4.8
University of Rajarata	2.9
University of Sabaragamuwa	2.8
University of Kelaniya	2.7
Open University	1.6
National School of Business Management (NSBM)	3.1
Sri Lanka Institute of Information Technology (SLIIT)	2.9
Other private universities	0.9

The accuracy level of the Lasso regression model was 73%, which is slightly higher than the accuracy level of the OLS, Ridge regression, and elastic net regression models (all at 72%). In contrast, the Bayesian regression model showed lower accuracy (61%), which can be neglected.

The detailed test results are presented in Figure 3, which shows the accuracy levels of each model. The results indicate that the Lasso regression model is the most suitable model for predicting the target variable in the given dataset. Furthermore, the mean squared error (MSE) and root mean squared error (RMSE) were calculated for each model to assess their predictive performance. Table 2 summarizes the performance of each model based on the evaluation metrics.

The Lasso regression model achieved the lowest MSE (0.038) and RMSE (0.19) values, indicating that it has the smallest average prediction error among all models and it is the best model for predicting the target variable. The R-squared value of the Lasso regression model was 0.73, indicating that 73% of the variability in the target variable can be explained by the independent variables in the model.

The Bayesian regression model had the lowest R-squared value of 0.61, indicating that it is the worst-performing model among the five regression models evaluated. Overall, the Lasso regression model was found to have the highest accuracy and best performance among the models evaluated. Therefore, it is recommended as the most suitable model for predicting the target variable.

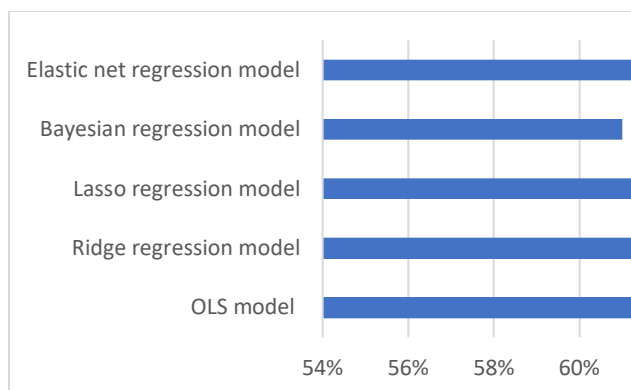


Figure 3. Accuracy level of each evaluated model

Table 2. Performance Metrics of Regression Models

Model	MSE	RMSE	R ²
OLS regression model	10.24	3.20	0.71

A regression analysis was conducted to examine the influence of online learning on students' lives. The study focused on students' academic performance, as measured by their CGPA, as the dependent variable.

Ridge regression model	10.35	3.22	0.70
Lasso regression model	9.98	3.16	0.73
Bayesian regression model	14.20	3.77	0.61
Elastic Net regression model	10.32	3.21	0.70

B. Effects of online learning and Model Relationships

Among the independent variables analyzed, prolonged use of digital devices and psychological factors stress, distraction, and loneliness were found to have a negative relationship with academic performance. Conversely, a strong internet connection showed a positive correlation with academic performance.

Table 3. Linear regression result for Academic performance with digital learning variables of Undergraduate students in Sri Lanka

Dependent variable	Independent variable									
Academic performance (CGPA)	Prolong Usage of digital Devices		Status of Internet connection		Physiological factors					
					Stress		Distraction		Loneliness	
	Model	Model	Model	Model	Model	Model	Model	Model	Model	Model
	r	R ²	r	R ²	r	R ²	r	R ²	r	R ²
	-0.891	0.793	0.974	0.949	-0.972	0.945	-0.996	0.992	-0.745	0.689

These findings indicate the impact of online learning on students' academic performance, highlighting the importance of considering digital device use and psychological factors when designing online learning environments. Only statistical data for variables that correlated are shown in Table 3.

The findings also suggest that online learning has varying impacts on theoretical and practical subjects. As

indicated in Table 4, a correlation analysis between CGPA and online theory and practical's was conducted. Interestingly, this study reveals that there is no significant correlation between CGPA and online theoretical subjects. However, taking online practical subjects has a negative impact on CGPA.

Despite the negative impact on academic performance, students express a willingness to continue their studies

through the Internet, emphasizing the benefits of online learning. As shown in Figure 4, students strongly recommended online learning, with a majority indicating a preference for continuing their studies online. The scale ranged from "strongly disagree" (1) to "strongly agree" (5).

Furthermore, Figure 5 highlights that the majority of students favor online exams. Most students expressed a willingness to take their exams online, provided they have a reliable internet connection and an undisturbed learning environment. The survey asked students to respond on a scale ranging from "yes" (1) to "never" (4), and the majority responded positively (yes-1).

A prevailing sentiment among the student body suggests that online learning induces a sense of isolation and lethargy, leading to occasional delays in the submission of online assignments. In response to the query "Have you submitted all online assignments on time?", 50.5% of the participants admitted to occasional lapses in punctuality, 48.9% claimed to submit online assignments within the stipulated time, while a mere 0.5% reported a consistent inability to meet the deadline. Upon analyzing the reasons for late submission of assignments, it was found that the majority of students provided more than one reason for their delay.



Figure 3. Student recommendations for online learning of undergraduates in Sri Lanka (Strongly Disagree – 1, Disagree – 2, Uncertain-3, Agree-4, Strongly Agree – 5)

Among the responses, it was observed that the primary reasons for late submission were laziness and poor internet connectivity, accounting for 33.4% and 31.4% of the responses, respectively. In addition, personal issues, time constraints, and power outages were also identified as major contributors to late submissions. Interestingly, some students acknowledged that their inadequate knowledge acquisition through online learning led to delayed submissions. This highlights the need for effective and targeted measures to improve students' understanding and comprehension of online course materials (Figure 6).

In response to the question, "Did you encounter technical or connectivity issues while learning online?" a considerable percentage of students responded in the

affirmative. Specifically, 72.3% of respondents indicated that they faced technical or connectivity issues occasionally, while 26.6% often encountered such problems. Only 1.1% of the respondents claimed to have never encountered any obstacles while learning online. It is noteworthy that the data for this study was collected via a Google Form, which required participants to have a decent internet connection. Therefore, it can be inferred that most students who participated in the study had a good or moderately strong internet connection.

Despite the aforementioned technical issues, the majority of students expressed their willingness to continue their studies online. However, they expressed a reluctance to continue with the practical component online, as they struggled to comprehend the practical aspects. On the

other hand, the students found online classes effective in understanding theoretical topics. To enhance students' performance, the practical aspects of online learning

should be reviewed, and factors such as technical and connectivity problems should be taken into consideration.

Table 4. Linear regression result for Academic performance with online theory and practical component among Undergraduate students in Sri Lanka

Dependent variable	Independent variable			
Academic performance (CGPA)	Online Theory		Online Practical	
	Model r	Model R ²	Model r	Model R ²
	NS	NS	-0.762	0.580

*NS – Not Significant

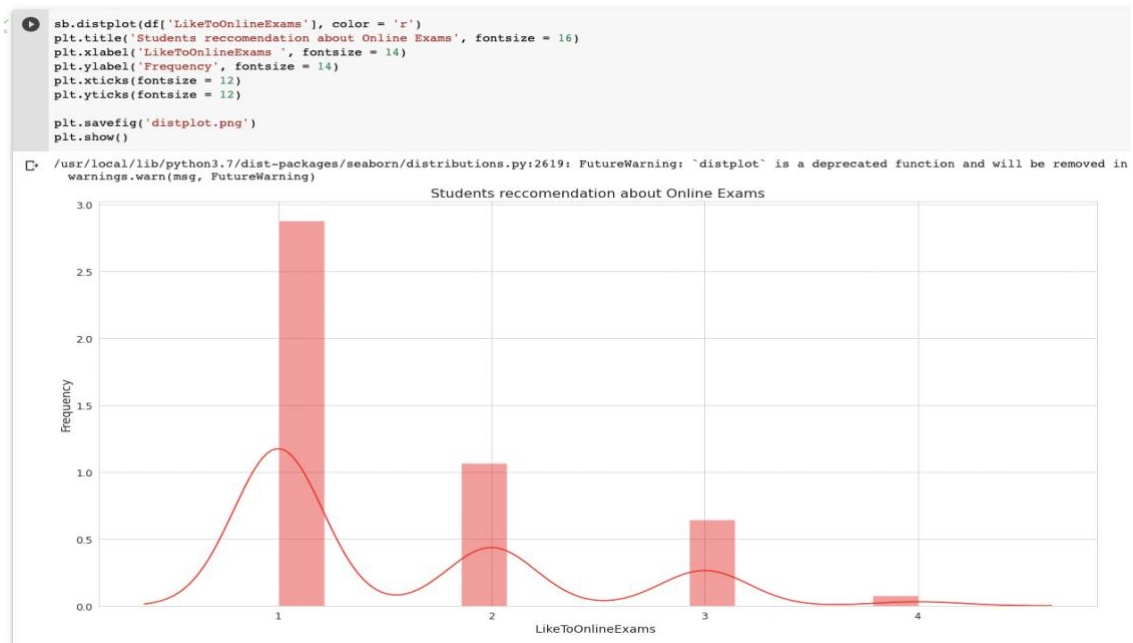


Figure 4. Student recommendation for online exams of undergraduate in Sri Lanka (yes-1, no-2, maybe-3, never-4)

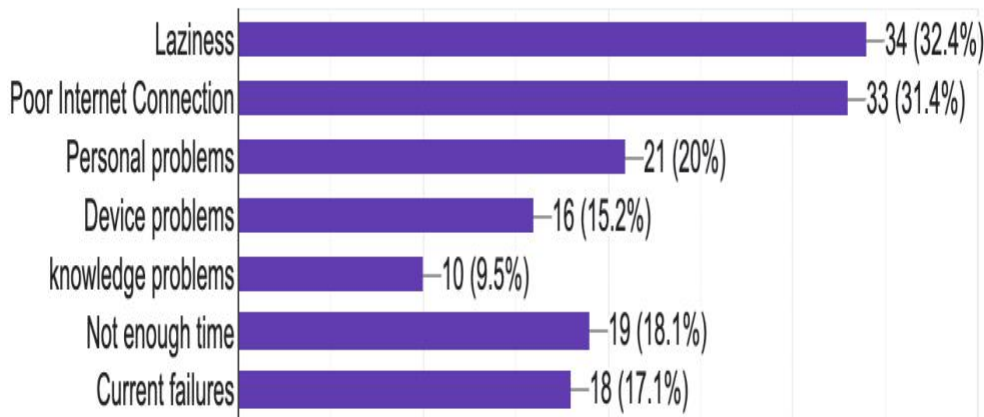


Figure 5. Identified reasons for late online assignment submission of undergraduate students in Sri Lanka

IV. DISCUSSION

The findings of this study highlight the challenges that Sri Lankan students have faced during the shift to online learning brought about by the Covid-19 pandemic. The travel restrictions imposed to contain the spread of the pandemic have had a cumulative impact on the traditional physical learning method practiced in many educational institutions in Sri Lanka. As a result, almost all educational institutions in the country converted their traditional learning methods to online learning, which allows distance learning without getting infected. Therefore, online learning has been a valuable tool for maintaining access to education during a time of crisis, it is clear that it is not without its limitations. A quick change in learning system without considering the challenges involved can have many impacts on students' lives.

The research received a total of 750 responses from students of various universities, and the majority of respondents (50.8%) were from the University of Ruhuna. The findings showed that before the pandemic, only 69.7% of students had previous experience with online learning sessions, and 30.3% had never experienced online learning sessions before the pandemic. Therefore, the study highlighted the relatively low level of exposure to and familiarity with online learning platforms among students in Sri Lanka.

The negative impact of prolonged use of digital devices and psychological factors on students' academic performance is particularly concerning. It is important for policymakers and educators to recognize the potential downsides of online learning and take steps to mitigate these effects. For example, providing students with strategies for managing stress and distraction and

promoting opportunities for social interaction can help address some of the psychological factors that may be negatively affecting their academic performance.

The positive correlation between a good internet connection and students' academic performance highlights the importance of ensuring equitable access to technology and internet infrastructure. This is especially relevant in developing countries like Sri Lanka, where access to technology and internet connectivity can be limited in certain areas. Providing students with the necessary tools and infrastructure to participate in online learning is essential to ensuring that all students have an equal opportunity to succeed.

The findings of this study are consistent with previous research conducted in Sri Lanka. For example, a study conducted by Wijewardene (2021) showed that the COVID-19 pandemic had a significant impact on higher education in Sri Lanka, with most universities transitioning to online learning platforms. However, students faced several challenges in adapting to the new online learning environments, including inadequate internet access, a lack of technical skills, and psychological issues. Another research conducted by Chandrasiri (2020) showed that online learning had a positive impact on student's academic performance, but it also highlighted the importance of considering students' socioeconomic background and psychological well-being.

According to the test result, online learning has become a necessary mode of education during the COVID-19 pandemic, but it has also threatened the human right to education in some cases. The digital divide and lack of access to reliable internet and technology have left many

students behind, particularly those from marginalized communities. In addition, online learning can be isolating and lack the social interaction that is essential for students' social development. Furthermore, online learning can exacerbate existing inequalities in education, such as discrimination against students with disabilities or those who require special accommodations. For instance, a study by the UNICEF Institute for Statistics found that 40% of low-income countries have not supported disadvantaged learners during school closures. As such, it is crucial to ensure that online learning does not infringe upon the human right to education and that all students have equal access to high-quality education (UNICEF, 2021).

The authors' recommendation for an interdisciplinary approach to strengthening the quality of online education in Sri Lanka is also noteworthy. Online learning requires a collaborative effort between educators, policymakers, and technology experts to develop effective teaching methods, ensure equitable access to technology and internet connectivity, and promote student engagement and motivation. The lessons learned from this pandemic can be used to inform the development of a sustainable online education system that can be used in future pandemics and beyond. According to our view, this is an initial attempt to quantify the effect of COVID-19 and online learning on Sri Lankan undergraduate academic performance. In light of our findings, we are highlighting the need for further scientific and interdisciplinary approaches with the following specific recommendations.

1. **Develop guidelines for online learning:** To address the negative impact of prolonged use of digital devices and psychological factors, policymakers could develop guidelines for online learning that include recommendations for managing screen time, taking breaks, and promoting student wellbeing. These guidelines could be communicated to students and educators through online platforms or other channels.
2. **Provide training for educators:** Many educators may not have experience with online teaching, so providing training and support for educators could help to improve the quality of online education. This training could include best practices for online teaching, strategies for promoting student engagement and motivation, and techniques for assessing student learning online.
3. **Improve online practical components:** The study found that online practical components showed a negative correlation with academic performance. To address this, policymakers and educators could explore alternative methods for delivering practical components online, such as virtual simulations or

remote lab access. Alternatively, hybrid models that combine online and in-person components could be explored.

4. **Address inequities in access to technology and internet connectivity:** The study found that a good internet connection had a positive correlation with academic performance, highlighting the importance of ensuring equitable access to technology and internet connectivity. Policymakers could explore initiatives to address inequities in access to technology and internet infrastructure, such as providing students with laptops or tablets, or investing in internet infrastructure in underserved areas.
5. **Foster a sense of community:** Online learning can be isolating, which can negatively impact students' engagement and motivation. To address this, educators could explore strategies for fostering a sense of community among students, such as group projects or online discussion forums. Additionally, policymakers could consider investing in online platforms that facilitate social interaction and collaboration among students.

Overall, these recommendations could help address the challenges of online learning in Sri Lanka and improve the quality of online education for students. By taking a holistic approach that addresses both the technical and social aspects of online learning, policymakers and educators can ensure that all students have access to high-quality education, regardless of the circumstances.

This study suggests that online learning does not affect all students equally. It depends on student mental health, Internet connectivity, digital literacy, and adaptability to online learning. Current teaching and learning techniques, curricula, policies, and current educational policies need to be changed to become catalysts for online education. For example, research shows that online sessions are not equally good for theory and practice. Consequently, instructional techniques, curricula, and materials need to evolve so they can be used with current technologies and deliver lessons that students can understand.

The understandable impact and weak educational policies underscore the need for an interdisciplinary approach to strengthening the quality of online education in Sri Lanka. Education policymakers and the government need to address online learning and develop new strategies for online learning that ensure equity, equality, and the moral right of students to have unfettered access to education. Many studies show that the effects of the pandemic are far from over. The knowledge and lessons learned from this pandemic must

be used to build a sustainable online education system for upcoming pandemics and the post-pandemic period.

In conclusion, this study highlights the challenges and potential of online learning in Sri Lanka during the COVID-19 pandemic. It emphasizes the need for policymakers and educators to address the limitations of online learning and work collaboratively to strengthen the quality of online education. Ultimately, the goal should be to ensure that all students have access to a high-quality education, regardless of the circumstances. The lessons we learn from COVID-19 will help us develop a higher education system that is resilient enough to meet unforeseen future challenges with the help of new technologies to ensure sustainable online education in Sri Lanka.

Conflicts of Interest

The authors declare no conflict of interest.

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