Model of e-Teaching and e-evaluation Methodology for Mathematics during COVID-19 Pandemic in Indonesia and Pakistan

Faqir M Bhatti^{1*}, Eka Miranda²

¹Riphah Institute of Computing and Applied Sciences, Riphah International University, Raiwind, Lahore. Pakistan, ²Information Systems Department, School of Information SystemsBina Nusantara University, Indonesia *fmbhatti@riphah.edu.pk, ekamiranda@binus.ac.id

Abstract: The rapid spread of the Covid-19 pandemic through the world has also created a disruption in the field of education. Students are unable to go to schools due to the Covid-19 pandemic. Technologies, such as the Internet tare widely used to support online learning. The objective of this paper is to discuss the result of e-teaching for Mathematics in Indonesia and Pakistan. This study examines student's performance in Mathematics in Indonesia and Pakistan. Data has been collected from a private university in Indonesia and Pakistan. They are Bina Nusantara (Binus) University and Riphah International University for the even semester 2019/2020. This study has examined the students' performance in Calculus and Linear Algebra for Undergraduate students. This study has found that the students could adapt to learning method changes in Calculus and Linear Algebra, from Blended/Hybrid (e-learning) to fully Online (e-learning) during the Covid-19 pandemic. The e-learning method could be implemented in Mathematics if the e-learning system is equipped with complete features and a complete learning system. This study has revealed rubric for each discipline must be carefully constructed looking at the ground reality and it may differ from country to country.

1. Introduction

Education is the key to escaping poverty, particularly with Science subjects. In2020, as the Covid-19 pandemic spread across the globe, almost all the countries announced temporary closure of schools and higher education institutes. The global pandemic has far-reaching consequences that may jeopardize hard-won gains made in improving global education [14]. The rapid spread of the Covid-19 pandemic through the world has also created a disruption in the education field. Around 91.3% or 1.5 billion students around the world are unable to go to schools due to the Covid-19 pandemic since April 2020 [14]. About 45 million students are unable to continue their learning activities in schools and Universities in Indonesia [7]. The Indonesian Ministry of Education and Culture then decided to suspend all academic activities in schools, colleges and universities and switched their academic activities to online learning from home. The education disruption due to the pandemic has put students from low-income families and rural areas at a disadvantaged position. These are the students who face barriers in access to education even in regular conditions (before Covid-19 pandemic). Now they need to overcome additional barriers due to the inequality of technology and telecommunication infrastructure in rural and remote areas in developing countries [14].

Technologies, such as the Internet, smartphones and laptops are now widely used to support online learning. Teachers and students meet through an online learning system to share teaching and learning material or to discuss a topic. Additionally, an assignment and an examination could be created through an online learning system or through other online testing platforms. The chief aim of this paper is to discuss e-teaching of Mathematics and the difficulties faced by teachers in teaching the subject. Moreover, students in Indonesia and Pakistan also faced difficulties in learning Mathematics during the pandemic.

2. Method

This study examines student's performance in Mathematics in Indonesia and Pakistan. Data was collected from private universities in both Indonesia and Pakistan. They are Bina Nusantara (Binus) University Indonesia and Riphah International University Pakistan for even semester 2019/2020. Mathematics is branched into (1) Pure Mathematics, Mathematics studied for its intrinsic interest, (2) Applied Mathematics, which is Mathematics that can be directly applied to real-world problems, (3) Discrete Mathematics and (4) Computational Mathematics, have emerged more recently [15].

Even semester begins on February 2020 and ends in July 2020 at Binus University. Half of the period of even semester runs during Covid-19 pandemic. Bina Nusantara has E-Learning Management Systems (called Binus Maya). Binus Maya has several features such as Assignments, Discussion Forums and Digital Content for courses. These features are used for two lecture modes which are face to face in the classroom and Guided Self Learning Class (GSLC). During this Covid-19 pandemic, all learning sessions changed to GSLC, equipped with video conferencing sessions. Data was collected for the Calculus course from undergraduate students. Two classes being collected as a sample. One class is from the Mathematics and Computer Science department and one class is from the Statistics and Computer Science department. Each class has 53 and 27 students respectively. This study was conducted in three phases: (1) Identify the goal of study, (2) Identify the method and (3) Identify result, discussion and conclusion



3. Result and Discussion

Online learning has three types [10]:

- 1. Web enhanced: Using internet technology to facilitate face-to-face patterns, it might use Learning Management Systems (LMS) or a website to post teaching materials and assignments.
- 2. Blended/Hybrid (e-learning): Combining online and face-to-face methods. There is a proportion of teaching material available online, usually supplemented by online discussions, and there is a reduction in face-to-face frequency.
- 3. Fully online (e-learning): Most or all teaching materials are delivered online, without any face-to-face portions at all.

Online learning has several benefits such as: flexibility, increased instructor - student time, access to expertise and low delivery costs [10],[11]. However, there are significant challenges in implementing online learning. Decrease in student learning motivation, inequality of technology and telecommunication infrastructure in rural areas, knowledge management and knowledge sharing

through e-learning systems LMS, e-Teaching methods and teacher quality are several challenges faced by Indonesia in implementing online learning [1],[2]. Whereas, technical teaching methods and learning material difficulties, access to computers, level of awareness (for students) and computer literacy are challenges for Pakistan in applying online learning [3],[6].

Before Covid-19 pandemic, all courses, including Mathematics, used Blended/Hybrid (elearning) system. Bina Nusantara University and Riphah International University. During Covid-19 pandemic, all courses changed to fully online (e-learning).

Study by [9] shows that the combined traditional classroom teaching and an e-learning systems more effective than traditional methods in improving attitudes towards Mathematics. It has been helpful in facilitating students when presenting their opinions. Moreover, it improves interaction amongst peers, and between students and teachers. Students benefit from group discussions and collaborative learning.

Study by [8] revealed significant difference between the mean scores for on-site and online students. It seems reasonable to conclude that it is possible for students in both onsite and online sections of a course to achieve equity in learning Mathematics.

Another study by [12] concluded that the e-learning method could help adult students who are studying Mathematics in the educational stage of high school. In this case, the improvements occur in motivation, autonomy, participation, concepts and results.

Assessments and examinations play a key role in the participation and performance rates of the students as well as for the e-teaching/e-learning systems. An examination as a formal test that students take to show their knowledge or ability in a subject also applied to the e-learning model. Students should be well informed and equipped with the technical requirements and appropriate computer skills. In addition, accessible technical support must be provided to students to complete online learning courses as well as assessment and examination. In recent years, online exams for students have been conducted via learning management systems (LMS) or other testing platforms [4]. A Calculus course for an Undergraduate student at Binus University has three components for the final score namely: Assignment, Mid-exam and Final-exam and weight of each component is 25%, 35% and 40% respectively. Similarly, data has been collected from Riphah Institute of Computing and Applied Sciences for the Linear Algebra course which was taught at undergraduate level before the Covid-19 and during Covid-19 pandemic period. During the weightage of quizzes and assignment and class participation was given as well as well as for the term examination. The results are shown in figures 3.1 to 3.4.

While examinations on e-learning systems has two methods namely: (1) Online synchronous examination through web video conference or online examination using e-learning system and (2) Online asynchronous examinations through e-learning systems [5].Table 3.1 shows online examination methods at Binus University and Riphah International university in Even semester 2019/2020.

 Table 3.1 Online examinations method in Binus University and Riphah International University in Even semester 2019/2020

Binus University		
Online examination methods Open Book Examination (Slot within Timed Window)		
Students get the take-home open-book problem-solving analysis examination for a timed window.		
1. End of Semester Written Work		
Research Paper, Literature review, Reports, Memos, Open ended Style Articles		
3. Oral Examination and Presentations online and Audiovisual Presentations		
4. Multiple choice questions		
Students get the multiple-choice questions for a timed window.		
Riphah International University		
1. Open Book Examination/take home examination or Open-book and take home		
a. Open Book Examinations		
All students get the take-home open- book examination at the same time, and must submit it back within the		
normal time required to complete the examination (e.g. two to four hours)		
b. Open Book Examination (Slot within Timed Window)		
Students get the take-home open-book examination for a timed window (e.g. 8 hours, 24 hours etc.).		
2. End of Semester Written Work		
Research Paper, Annotated Anthology, Bibliography, or Literature Review, Reports, Memos, Open ended		
Style Articles, Reflection Paper		
3. Oral Examination and Presentations		
a. Class Presentations(online)		
b. One-on-One Oral Examination		
c. Audiovisual Presentations		
Discouraged methods (not generally viable under present conditions)		
Closed Book Examinations and Multiple-Choice Questions (MCQs) are discouraged under the prevailing situation.		

Assessing student performances for a course is one tool to evaluate curriculum achievement. A rubric for assessment, usually in the form of a matrix or grid, is a tool used to interpret and grade students' work against criteria and standards [13]. Assessment rubric has been implemented for primary education and higher education level [13]. Assessment rubric has been implemented for natural sciences, social sciences, humanities and applied sciences [13]. Assessment rubric has been implemented for elearning system as well [1]. Table 3.2 and Table 3.3 shows an example of online examination question and assessment rubric on the undergraduate level for Calculus at Binus University Indonesia and Riphah International University Pakistan respectively.

 Table 3.2 Online examination question

	Online examination question	
Binus University		
Course name: Calculus2 for undergraduate		
1. Identify the derivative of the following function: $f(x) = \ln(3x)$		
a. $f'(x)=3\ln(3x)$	c. $f(x)=1/x$	
b. $f'(x) = 1/3x$	d. $f(x) = 3/x$	
2. Given two variables function z Determine a. $\frac{\partial^2 z}{\partial x \partial y}$ b.	$= 8\sin(xy) - xy^{3} + \frac{x^{2}}{y^{4}}$ $\frac{\partial^{2}z}{\partial y \partial x}$	
Exam policy:		
Students get the take-home open-book examination and need a login to answer Calculus examination for a time window (100 minutes). The exam consists of 31 questions (1 essay, score weight 10%, 30 multiple choices, score		

weight 90%). Lecturer team has a lot of examinations questions. Students can resubmit the answer for 7 days ahead. If a student wants to resubmit the answer, then she/he must ask permission from Lecturer Service Center (LSC) for login subsequently answer the question for 100 minutes time window and questions displayed randomly. No student gets the same question.

Riphah International University

Course Name: Linear Algebra for undergraduate

Q.1 Suppose that the characteristic polynomial of some matrix A is found to be

$$P(u) = (u - 2)^2(u - 4)(u + 1)^2$$

- a. What can you say about the dimensions of the eigenspaces of A?
- b. What can you say about the dimensions of the eigenspaces if you know that A is diagonalizable?
- c. If $\{v_1, v_2, v_3\}$ is a linearly independent set of eigenvectors of A, all of which correspond to the same eigenvalue of A, what can you say about that eigenvalue?
- Q2 Let \mathbb{R}^3 have the inner product

$$< u, v > = u_1v_1 + 2u_2v_2 + 3u_3v_3$$

Use the Gram-Schmidt process to transform $u_1 = (1,1,1)$, $u_2 = (1,1,0)$, $u_3 = (1,0,0)$ into an orthonormal basis.

Above is an example for students to give answers of both questions and MCQ. It is a take-home and open book examination for linear algebra. Their answers would be judged and based on their concepts of characteristic polynomial, dimensions, eigenspace and whether the matrix A is diagonalizable or not. In the same take-home question, it should be judged whether student knows the concept of linearly independent set of eigenvectors of A and eigenvalues. In the second question, it should be judged whether student knows the concept of Gram Schmidt process. The examination consists of four to five questions and the allowed time is 4 hours for answering all the questions and upload on a given website (like Moodle or Moellim). If any student faces connectivity problem or electricity failure, more time should be given and must be approved by the examination committee. No make up examination would be allowed.

Table 3.3 Assessment rubric

Assessment Rubric and its implementation

Binus University, Jakarta, Indonesia Assessment rubric for a Calculus 2 Course.

Excellent mark (85-100%)

- 1. The method to compute limits and derivative are correctly chosen, the steps performed are correct and accurate
- 2. The method to compute integral is correctly chosen, the steps performed are correct and accurate
- 3. The method to solve the application is correctly chosen, the steps performed are correct and accurate
- 4. The method to identification is correctly chosen, the steps performed are correct and accurate
- 5. The expression of the function as a Taylor and McLaurin series are relevant and clearly stated
- 6. Concept and ideas are relevant and clearly stated
- 7. The method to solve ODE is correctly chosen, the steps performed are correct and accurate

Good mark (75-84%)

- 1. The method to compute limits and derivative are correctly chosen, the steps performed are correct but inaccurate, and the solution is incomplete
- 2. The method to integral is correctly chosen, the steps performed are correct but inaccurate, and the solution is incomplete
- 3. The method to solve the application is correctly chosen, the steps performed are correct but inaccurate, and the solution is incomplete
- 4. The method to identification is correctly chosen, the steps performed are correct but inaccurate, and the solution is incomplete

- 5. The expression of the function as a Taylor and McLaurin series are correct
- 6. Concept and ideas are competent
- 7. The method to solve ODE is correctly chosen, the steps performed are correct but inaccurate, and the solution is incomplete.

Average mark (65-74%)

- 1. The method to compute limits and derivative are correctly chosen, but the step performed, and solutions are inappropriate.
- 2. The method to integral is correctly chosen, but the step performed, and solutions are inappropriate
- 3. The method to solve the application is correctly chosen, but the step performed, and solutions are inappropriate
- 4. The method to identification is correctly chosen, but the step performed, and solutions are inappropriate
- 5. The expression of the function as a Taylor and McLaurin series are incomplete
- 6. Concept and ideas are incomplete
- 7. The method to solve ODE is correctly chosen, but the step performed, and solutions are inappropriate

Poor mark (0-64%)

- 1. The method to compute limits and derivative are inappropriate chosen, the steps performed are incomplete steps, and the solution is wrong.
- 2. The method to compute integral is inappropriate chosen, the steps performed are incomplete steps, and the solution is wrong
- 3. The method to compute integral is inappropriate chosen, the steps performed are incomplete steps, and the solution is correct
- 4. The method to solve the application is inappropriate chosen, the steps performed are incomplete steps, and the solution is wrong
- 5. The method to identification is inappropriate chosen, the steps performed are incomplete steps, and the solution is wrong
- 6. The expression of the function as a Taylor and McLaurin series are inadequate and there are logical inconsistent
- 7. Concept and ideas are inadequate and there are logical inconsistent
- 8. The method to solve ODE is inappropriate chosen, the steps performed are incomplete steps, and the solution is wrong.

Riphah International University, Lahore. Pakistan

For Excellent (100%)

- 1- Concepts of the topic are cleared
- 2- Submitted on or before deadline
- 3- Explanation description and justification are clearly written
- 4- Writing may include details and examples

For Good Marks (90%-80%)

- 1- Concepts are cleared
- 2- Submitted on or before deadline
- 3- Solution output is correct
- 4- Explanation description and justification may lack clarity.
- For average marks (70%-50%)
- 1- Concepts are partially cleared
- 2- Mistakes/copied from internet/from another student(s)
- For below average (<50%)
- 1- Concepts are not cleared/wrong attempt
- 2- Submission is overdue date
- 3- Copied from online source/web

Figure 3.1 and Figure 3.2 show student's performance for Calculus with e-learning systems on even semester 2019/2020 during Covid-19 pandemic.



Figure 3.1 Students performance for Calculus (Mathematics and Computer Science Department with 53 students)



Figure 3.2 Students performance for Calculus (Statistics and CS department with 27 students)

Students could adapt with learning method changes for Calculus and Linear Algebra courses from Blended/Hybrid (e-learning) to Fully online (e-learning) during the Covid-19 pandemic. About 60% of students in Calculus get an A or B score. Moreover, 27% students get A grades in Linear Algebra.





Figure 3.3



Figure 3.4 Students performance for Linear algebra (Mathematics and Computer Science Department with 30 students during COVID19, at Riphah Int. University) and 24% students got A grade only.

The results of this study are in accordance with the study by [12]. E-learning method could be implemented in Mathematics as long as e-learning system is equipped with complete features and a complete learning system. Moreover, several challenges for Mathematics in e-learning method should be answered. How to improve student's motivation, participation, interaction (with other students and teachers) and collaborative learning is a challenge to solve.

4. Conclusion

This study revealed e-learning method could be implemented in Mathematics. Universities have already designed online exam method and assessment rubric to maintain the quality of teaching and learning outcomes. We argue that Rubric for each discipline must be carefully constructed looking at the ground reality and it may differ from country to country. It is because of e-learning and e-evaluations of examinations is totally based on the environment in which you are delivering the course. This study also revealed students could adapt with learning method changes for Calculus from Blended/Hybrid (e-learning) to Fully online (e-learning) during the Covid-19 pandemic. The finding of this study suggests e-learning system is equipped with complete features and a complete learning system to facilitate online learning method. This study examines only Calculus and Linear Algebra for Undergraduate level at Bina Nusantara (Binus) University Indonesia and Riphah International University Pakistan. Future work could examine the result of other courses in the Mathematics field when using the e-learning system. Also, the number of University samples in Indonesia and Pakistan could be added to get an increased finding on the impact of e-learning Mathematics.

Acknowledgements We appreciatively admit the support from Riphah Institute of Computing and Applied Sciences, Riphah International University, Raiwind, Lahore. Pakistan; Research and Technology Transfer Office (RTTO), Bina Nusantara University who provided insights and expertise that has greatly assisted the research.

References

- [1] Ardiansyah, R., Diella, D. (2019). Implementation of E-learning Based on Assessment For Learning To Improve Student Learning Performance. the Journal of Biology and Biology Education, 3(1), 6-13
- [2] Asian Development Bank (2015). *Reviews of National Policies for Education in Indonesia Rising to the Challenge*. Asian Development Bank
- [3] Bughio, I. A., Abro, Q. M. M., Rashdi, P. R. S. (2014). *Effective Online Distance Learning In Pakistan and Challenges*. International Journal of Management Sciences, 2(6), 274-279
- [4] Cramp, J., Medlin, J. F., Lake, P., Sharp, C. (2019). (2020). Lessons Learned From Implementing Remotely Invigilated Online Exams. Journal of University Teaching & Learning Practice, 16(1), 1-20
- [5] Frank, G., Bitter, S. S. (2012). Online Exams: Practical Implications and Future Directions. Proceedings E-Learning. European Conference. 11th, Groningen, Netherlands: University of Groningen
- [6] Ijaz, A. Ilyas, Q. K., Yasmin, R., Whitty, M. (2012). Challenges of implementing e-learning in a Pakistani University. Knowledge Management & E-Learning: An International Journal, 4(3) 310-324
- [7] Indonesia Central Bureau of Statistics (BPS). (2019). Indonesian Education Statistics 2019. https://www.bps.go.id/publication/2019/11/29/1deb588ef5fdbfba3343bb51/potret-pendidikanstatistik-pendidikan-indonesia-2019.html. Accessed June 1, 2020
- [8] Jones, S. J., Long, V. M. (2013). Learning Equity between Online and On-Site Mathematics Courses. MERLOT Journal of Online Learning and Teaching, 9(1), 1-12
- [9] Lin, Y. W., Tseng, C. L., Chiang P. J. (2017). *The Effect of Blended Learning in Mathematics Course*. EURASIA Journal of Mathematics Science and Technology Education, 13(3), 741-770
- [10] Ministry of Research and Technology (RISTEKDIKTI). (2016). Distance Learning and E-Learning Policy in Indonesia. http://kopertis3.or.id/v2/wp-content/uploads/Paulina-Pannen-Kebijakan-PJJ-dan-E-Learning.pdf. Accessed June 7, 2020
- [11] Ministry of Research and Technology (RISTEKDIKTI). (2019). Distance Learning Implementation, http://lldikti12.ristekdikti.go.id/wp-content/uploads/2019/01/III.2-DITJEN-KELEMBAGAAN-PJJ-RAKER-2019-1.pdf. Accessed June 7, 2020
- [12] Moreno-Guerrero, A. J., Aznar-Díaz, I., Cáceres-Reche. P., Alonso-García, S. (2020). *Learning in the Teaching of Mathematics: An Educational Experience in Adult High School.* Mathematics, 8(5), 1-16
- [13] Segara, N. B. (2014). Use of Rubric as An Alternative Assessment in The Social Studies Seminar Course. the Journal of Edunomic (Economic Education), 2(2), 1-7
- [14] United Nations (UN), (2020). Sustainable Development Goals. https://www.un.org/sustainabledevelopment/education/. Accessed June 19, 2020
- [15] Yadav, D. K. (2017). Exact Definition Of Mathematics. International Research Journal of Mathematics, Engineering and IT, 4(1), 34-42