EXAMINING THE ACHIEVEMENT OF COURSE AND PROGRAM OUTCOMES FOR THE STRENGTH OF MATERIALS COURSE DURING THE COVID-19 PANDEMIC

R. Othman, M.R. Aziz* and A.M. Shah

Mechanical Engineering Studies, College of Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Kampus Permatang Pauh, Penang, Malaysia.

*Corresponding email: man@uitm.edu.my

Article history
Received
23rd April 2023
Revised
29th October 2023
Accepted
18th November 2023
Published
1st December 2023

ABSTRACT

The pandemic due to Covid-19 in 2020 had a substantial impact on teaching and learning of educational courses, including lectures, labs, workshops, and assessments. In this study, Strength of Materials course was selected in analyzing the achievement of program and course outcomes during the pandemic. This course is a mechanical engineering core course for all students enrolling Diploma in Mechanical Engineering at Universiti Teknologi MARA, Penang Branch. Three course outcomes were mapped to three program outcomes respectively. The findings revealed that there were variations in the attainment of all course outcomes particularly the outcome related to higher cognitive domain. Therefore, it can be concluded that the pandemic has influenced the overall achievement of course and program outcomes in Strength of Materials course.

Keywords: *Covid-19, program outcome, course outcome, assessment*

1.0 INTRODUCTION

Outcome-based education (OBE) has gained importance in the field of engineering education, as demonstrated in several studies reviewed. These studies have investigated various assessment and evaluation methods to measure program outcomes (POs) and course outcomes (COs) and highlighted the effectiveness of active and contextual learning methods, OBE, and continuous quality improvement (CQI) approaches. The studies also emphasized the importance of incorporating real-world projects, implementing continuous assessment and evaluation, and utilizing various assessment methods. A.A. Mutalib et al. [1] described a study on measuring program outcome (PO) in Civil Engineering programs at Universiti Kebangsaan Malaysia (UKM). The authors investigated six program objectives and twelve program outcomes, measuring them in five specific courses. They used various methods to evaluate PO achievement, including assessments, surveys, and analysis of course materials. The study concluded with a comparison between the measurements of PO achievement by lecturers and by final year students, providing a useful reference for lecturers in the future. J.S. Thomas et al. [2] explored the use of an asynchronous format for teaching mechanics of materials in a problem-solving course. Asynchronous delivery relies heavily on internet delivery of instructional materials, making it a viable option for instructors with large classes or heavy workloads. The authors found that student performance remained high with the use of asynchronous delivery and suggest that it can be an effective way to teach engineering courses. Although the study identified some differences in performance between higher and lower-ability students, these differences were not statistically significant.

DOI: https://doi.org/10.11113/jm.v46.497

The evaluation of program outcomes (POs) for a Reinforced Concrete Design course at UKM was conducted by S.A. Osman et al. [3]. The effectiveness of the continuous quality improvement (CQI) approach was assessed by comparing the PO achievement of students in two sessions. The study found that the CQI approach increased PO achievement by 9-39% in the second session compared to the first. The authors emphasized the importance of real-world projects in achieving POs, as the course requires students to work on design projects related to actual structural design projects. In another study, S.A. Osman et al. [4] evaluated course outcomes (COs) for Civil Engineering Design II at UKM. The authors measured the achievement of eight COs using various assessment methods, including written reports, bill of quantities reports, presentations, and peer assessments. CO6 and CO8 were found to have the highest overall levels of achievement, while CO7 had the lowest achievement level among all the COs. The study highlighted the significance of continuous assessment and evaluation in improving teaching and learning methods.

In their study, Boulatoff and Cyrus [5] discussed the challenges faced in large introductory courses and suggested ways to improve student outcomes. They observed that incorporating active learning methods such as group discussions and activities enhanced student engagement and performance. Similarly, K.R.A. and Hunashyal [6] explored the benefits of contextual learning in enhancing students' understanding of mechanics of material concepts, concluding that real-world examples can help students comprehend complex theories and improve learning outcomes. Gutierrez-Bucheli et al. [7] reviewed the literature on sustainability in engineering education and identified the positive impact of incorporating sustainability topics on critical thinking and problem-solving skills. Additionally, Jadhav et al. [8] evaluated the effectiveness of outcome-based education in engineering and found that it helped students develop practical skills and problem-solving abilities.

Earlier on, G. Na et al. [9] examined the effectiveness of laboratory courses in achieving program outcomes and found that structured evaluation of laboratory content improved students' understanding of fundamental concepts and their practical skills. Similarly, T. Hernandez et al. [10] evaluated the outcomes of remote pathology instruction and reported that it did not have a significant impact on students' performance or course evaluation. In another study, W. Bosshardt and E.P. Chiang [11] explored the long-term impact of online principles courses on students' outcomes and found that students who took online courses performed similarly to those who took in-person courses, with no negative impact on their long-term outcomes. Lastly, X. Wei et al. [12] conducted a systematic review of the literature on massive open online courses and concluded that these courses can effectively achieve cognitive, behavioral, and affective learning outcomes.

Nevertheless, the world was shocked by the emergence of Covid-19 disease and it had evolved from the epidemic to the pandemic situation as the number of cases spiked to a worldwide population [13]. Consequently, the physical existence in teaching and learning was replaced by the use of online technology. The United Nations' scientific and cultural organizations proposed the use of various technologies to enable the continuity of teaching and learning despite the limitations faced by the teachers and students due to the pandemic nationwide. Teachers could use online learning platforms to teach, interact, and provide virtual training sessions [14]. Similarly, an assessment is an important aspect that can be conducted via online activities, such as assignments, projects, quizzes, and tests. Nonetheless, there are concerns regarding the level of difficulty in online assessments. Apart from that, the level of privacy and confidentiality in virtual education should be observed to allow for the effective assessments even though the online methods may seem new following the announcement by the Kementerian Pengajian Tinggi (KPT). Furthermore, practical assessments could be more challenging when assessed virtually [15].

In 2023, D.R. Selvam et al. [16] studied stress levels in higher education students using e-learning during the COVID-19 pandemic. The research highlighted increased stress due to sudden academic changes and personal factors, with greater stress from academic adaptations, family dynamics, and individual circumstances. In a separate study, D. Wang et al. [17] focused on sub-Saharan African adolescents, revealing ongoing pandemic challenges for education and well-being. Collaborative efforts were emphasized. The pandemic led to global education shifts to online teaching, exposing challenges in skills, resources, and technology. E.F. Okagbue et al. [18] found

 DOI: https://doi.org/10.11113/jm.v46.497

digital proficiency issues in Nigeria, hindering web-based learning. Then, F. Recch et al. [19] explored worldwide school closures, stressing data improvement for recovery. Next, Salsabila Isha and Bambang Wibawarta [20] identified a tech gap in Japan's basic education. Furthermore, H. Akabayashi et al.[21] linked family background to online education access disparities. In addition, J Ferrer et al. [22] analyzed university students' academic changes during the transition to in-person learning. Positive online perceptions correlated with better performance. On top of that, R. Imran et al. [23] proposed blended teaching post-pandemic, and R. Mahajan et al. [24] emphasized themes like digital learning and collaboration. Currently, A. Abidemi et al. [25] introduced a model to assess Covid-19's impact on higher education.

In summary, these literature reviews demonstrate the significance of assessment and evaluation in improving the quality of engineering education despite the emergence of Covid-19 pandemic. They suggest that the use of active and contextual learning methods, outcome-based education, and continuous quality improvement approaches can enhance students' understanding of fundamental concepts and improve their practical skills. The studies also highlight the importance of incorporating real-world projects and sustainability topics in engineering courses to develop students' critical thinking and problem-solving abilities. Furthermore, the effectiveness of online courses in achieving long-term learning outcomes suggests their potential to enhance the accessibility of engineering education. Overall, the findings of these studies provide useful insights and recommendations for educators to improve the quality of their engineering programs and enhance students' outcomes. Nonetheless, the challenge is to ensure the quality of teaching and learning will be maintained even using online technology due to pandemic. Therefore, it is important to investigate the comparison of student achievement during and after the pandemic since the teaching and learning is different.

The present investigation covers on the attainment of Course Outcomes (COs) for the Strength of Materials course. The achievement of COs will affect Program Outcomes (POs) as well since both CO and PO are mapped accordingly. The scope of this study is on individuals who enrolled in the course from July 2020 to February 2023 and it is during the Covid-19 pandemic and after the pandemic. This course is a mandatory component for Mechanical Engineering students pursuing Diploma in Mechanical Engineering in their first semester of second year. Additionally, the assessment of the evaluation process during this timeframe is also analyzed.

2.0 METHODOLOGY

This study focuses on students who were enrolled in the Strength of Materials course from July 2020 to February 2023, which is compulsory for second-year, first-semester students pursuing a Diploma in Mechanical Engineering. Students must have obtained a minimum grade of C in the Statics course in the preceding semester to be eligible for this course. The Strength of Materials course is a prerequisite for two other courses. The Strength of Materials course is of great significance, covering six chapters that must be taught in 14 weeks, with 3 credit hours. Students attend three hours of lectures and one hour of tutorials each week, with the average number of attendees ranging from 20 to 30 students. Failure to pass the Strength of Materials course may lead to a prolonged semester for students.

Table 1 outlines the program outcomes (POs) and course outcomes (COs) for Strength of Materials. The course focuses on three POs and three COs. PO1 is to Apply knowledge of applied mathematics, applied science, engineering fundamentals and an engineering specialization to wide practical procedures and practices. Then, PO2 is to identify and analyze well-defined engineering problems reaching substantiated conclusions using related methods of analysis specific to their field of activity. Lastly, PO3 is to Design solutions for well-defined technical problems and assist with the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

COs include CO1, which describes the basic concepts and fundamental principles in strength of materials. CO2 and CO3 focus to analyze simple mechanical members problems using basic

 DOI: https://doi.org/10.11113/jm.v46.497

concepts and fundamental principles of strength of materials, and to evaluate loads and stresses in mechanical members using knowledge of strength of materials, respectively. The cognitive domain represents the domain for Strength of Materials, as shown in Table 2, which indicates the percentage of assessment questions for each assessment type, including quiz, test, assignments, and final exam.

Table 1: PO-CO Mapping

	PO1	PO2	PO3
CO1	/		
CO2		/	
CO3			/

Table 2: Cognitive Domain in Strength of Materials

Cognitive Level	Percentage (%)
C1-C2	20
C3-C4	60
C5-C6	20

The data collected was based on the overall results of the students taking the course for each semester. The overall results were referred to the total marks from all the assessments taken by the students. The results of the students were then analysed based on the achievement of COs. Since the mapping of COs was one-to-one with POs, the results of POs were similar with the COs.

3.0 RESULTS AND DISCUSSION

3.1 Introduction

This section describes the CO achievement from July 2020 to February 2023, where the July intake includes newly admitted students in the Strength of Materials course. However, the February intake is designed for students who are repeating the course. It's important to mention that in certain cases, students who retake the Statics course may join the Strength of Materials course with other repeaters, even if it's their first attempt at taking Strength of Materials. During the pandemic, the teaching method was based on synchronous and asynchronous approach. In synchronous method, the lecturer used online platform to carry out the lecture in real-time with the students such as Google Meet, Webex and Microsoft Teams. On the other hand, in the asynchronous approach, the students also learned the subject via recorded lecture. Similarly, the assessments were carried out by using online platform such as Google Classroom, Microsoft Teams and uFuture (UiTM online platform for blended learning).

.

3.2 CO1 Attainment

Figure 1 presents notable fluctuations in the attainment of CO1 over time. For instance, the CO1 attainment for February 2020 was 74% and it rose to 99% in February 2021. Nevertheless, the CO1 attainment decreased drastically to 44% in July 2021. It is due to the fact that quiz was the only method of assessment for CO1 and it was differed from other semester. Thus, the achievement of students was solely based on quiz. Despite this, there was an increase in February 2022. After that, the CO1 attainment dropped to 59% in February 2023. The data implies that the CO1 attainment has experienced considerable variation over recent years.

DOI: https://doi.org/10.11113/jm.v46.497

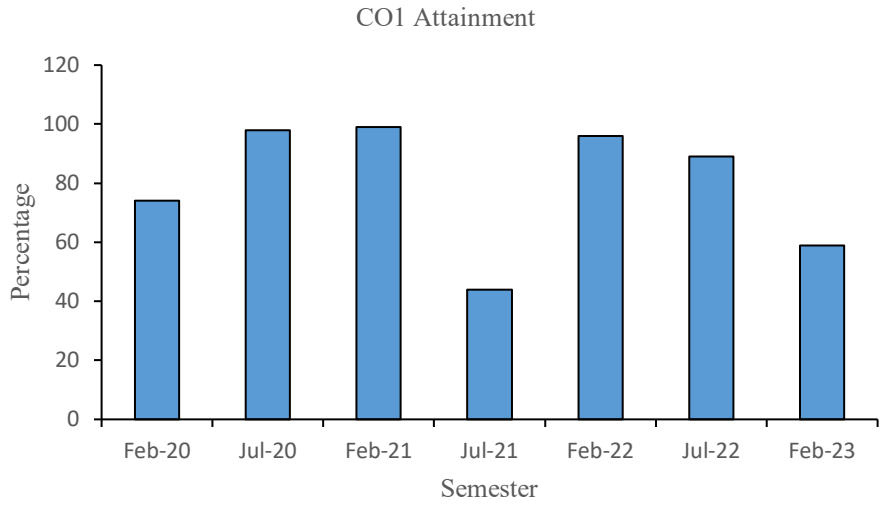

Figure 1: CO1 attainment from Semester February 2020 until February 2023.

3.3 CO2 Attainment

The CO2 attainment presented in Figure 2 exhibits fairly constant performance from February 2020 until February 2023. The highest CO2 attainment was February 2021 with all students attained the outcome of CO2 and none was failed. However, after that, the percentage was reduced but bounced back in February 2022. In the following two consecutive semesters, the percentage was decreased gradually. Overall, the data revealed that in February, the performance of students was low compared to other semester and it is due to different cohort of students. These students are from post pandemic cohort, thus method of teaching and assessment are different for this batch of students.

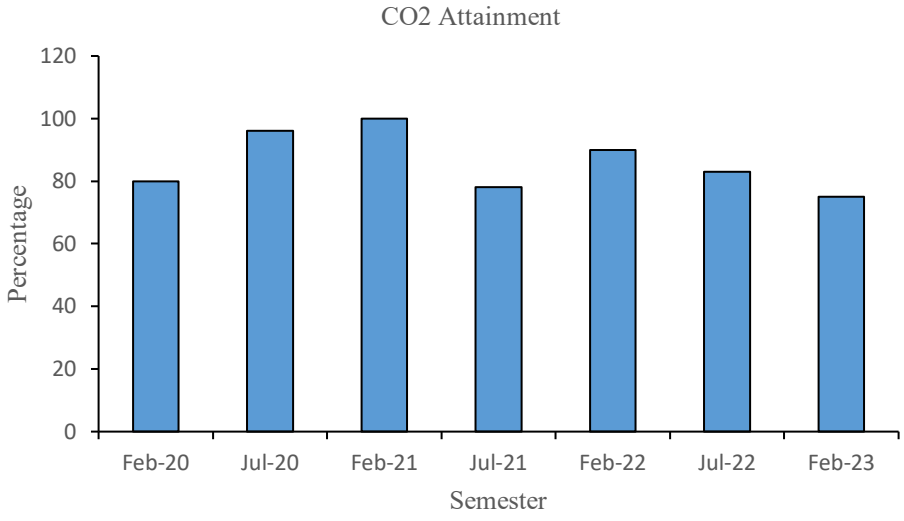

Figure 2: CO2 attainment from Semester February 2020 until February 2023

3.4 CO3 Attainment

Figure 3 depicts the percentage of CO3 attainment in every semester from February 2020 until February 2023. The percentage was increased in July 2020. After that, the percentage was gradually fall and reached to the lowest percentage of 22% in July 2022. The reason of this downfall was due

DOI: https://doi.org/10.11113/jm.v46.497

to the final test that was not answer satisfactorily. The question related to CO3 was about the topic of stress transformation. Thus, as for continuous quality improvement, teaching method for the topic need to be emphasized. This approach showed good result since the CO3 attainment in February 2023 was rose up drastically. The data suggests that the attainment of CO3 had remained consistently low compared to other CO1 and CO2 attainments. It is because CO3 addresses higher cognitive domain, C5 and the questions are more difficult to answer as compared to CO1 and CO2 which address cognitive domain C2 and C4 respectively.

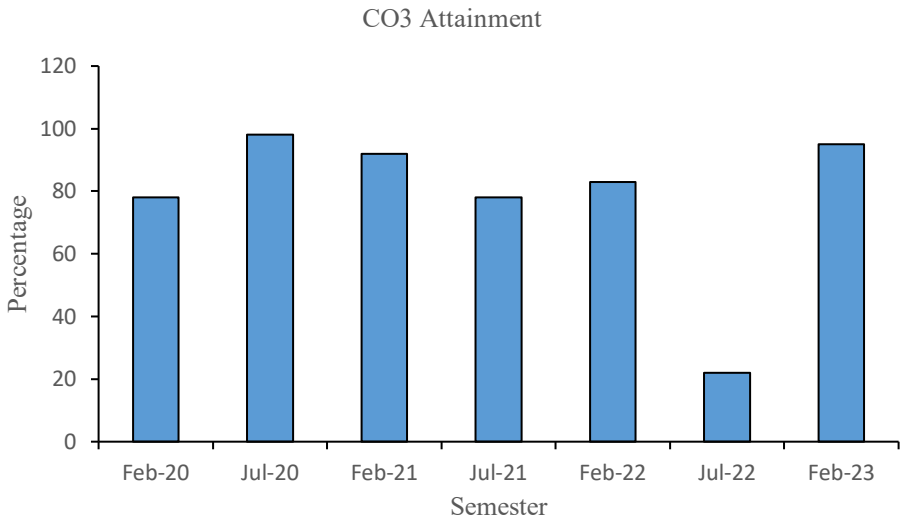

Figure 3: CO3 attainment from Semester February 2020 until February 2023

3.5 Assessment

Throughout the course, various assessment methods were used, including quizzes, tests, assignments, and a final exam. Due to the Covid-19 pandemic, all assessments were conducted online except for the February 2023 semester, which had a different arrangement. During that semester, the teaching and assessments were carried out face-to-face.

Table 3 shows the assessment percentage designed for this course. The weightage for quiz was 10% and only used in the July 2021 semester. For Test, the weightage was 20% across all semesters except July 2021. The weightage for Assignment 1 was varied with the highest weightage in July 2020 and February 2021. In July 2021, the weightage was 25%, while in February 2023, it was the lowest at 10%. Assignment 2 had a similar weightage. In contrast, the weightage for the final exam increased over time, with the lowest weightage being 20% in the first two semesters and the highest weightage being 50% for the three latest semesters, from February 2022 to February 2023.

Table 3: Assessment for Strength of Materials

Semester	Quiz (%)	Test 1 (%)	Assignment 1 (%)	Assignment 2 (%)	Final Exam (%)
July 2020	-	20	30	30	20
February 2021	-	20	30	30	20
July 2021	10	0	25	25	40
February 2022	-	20	15	15	50
July 2022	-	20	15	15	50
February 2023	-	20	10	10	50

DOI: https://doi.org/10.11113/jm.v46.497

Table 4 shows the course outcomes (COs) that were assessed during each evaluation. The quiz conducted in July 2021 only evaluated CO1, while CO2 and CO3 were not assessed in any of the quiz. On the other hand, for the test, all COs were evaluated in the tests for all semesters, except for the July 2021 semester. CO1 was assessed in two consecutive semesters (July 2021 and February 2022) through assignments, while CO2 was evaluated in all semesters. CO3 was assessed in the same semester as CO1, with an additional evaluation in February 2023. Finally, all three COs were assessed in the final exam for all semesters.

Table 4: Details of CO in Assessment (continued)

	Quiz			**Test**		
Semester	CO1	CO2	CO3	CO1	CO2	CO3
Jul-20				/	/	/
Feb-21				/	/	/
Jul-21	/					
Feb-22				/	/	/
Jul-22				/	/	/
Feb-23				/	/	/

Table 4: Details of CO in Assessment

	Assignment			**Final Exam**		
Semester	CO1	CO2	CO3	CO1	CO2	CO3
Jul-20	/	/	/	/	/	/
Feb-21	/	/	/	/	/	/
Jul-21		/		/	/	/
Feb-22		/		/	/	/
Jul-22		/		/	/	/
Feb-23		/	/	/	/	/

4.0 CONCLUSION

From the study, it can be concluded that:

- There have been significant fluctuations in the attainment of CO1 over time due to difference in method of teaching and assessment. However, despite the fluctuations, the efforts to improve the attainment of CO1 have been carried out to increase the percentage of attainment.
- For CO2 attainment, there has been a fairly constant trend in attainment over the years. Cohort of student plays important factor influencing the attainment of CO2 especially in comparison of cohort between during and after the pandemic.
- The attainment for CO3 was relatively low because the domain of cognitive level is higher, C5. The improvement in February 2023 could be possibly due to change in assessment method (assignment).
- The assessment of COs was varied across different type of assessments and semesters. The variation in the evaluation of COs might have affected the overall attainment percentage for each CO as shown in the result of CO1, CO2 and CO3.

DOI: https://doi.org/10.11113/jm.v46.497

ACKNOWLEDGMENT

The authors would like to thank Mechanical Engineering Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang for the support.

REFERENCES

1. Mutalib A.A., Rahmat R.A.A., Rashid Abd. K. Abd., Suja, F. and Sahril, S., 2012. Measurement and Evaluation of Program Outcomes in the Civil Engineering Courses, *Procedia - Social and Behavioral Sciences*, (60):p 333 – 342.
2. Thomas J.S., Hall R.H., Philpot T.A. and Carroll, D.R., 2011. The Effect of On-Line Videos on Learner Outcomes in a Mechanics of Materials Course, Proceedings *of the 118th ASEE Annual Conference and Exposition*, *American Society for Engineering Education (ASEE)*.
3. Osman S.A., Badaruzzaman W.H., Hamid R., Taib K.A. and Rashid, A.K., 2011. The Program Outcomes Achievement for Basic Reinforced Concrete Design Course between Two Different Sessions, *Procedia - Social and Behavioral Sciences*, (18):p 260–265.
4. Osman S.A., Jaafar O., Badaruzzaman, W.H. and Rahmat R.A.A.O.K., 2012. The Course Outcomes (COs) Evaluation for Civil Engineering Design II Course, *Procedia - Social and Behavioral Sciences*, (60):p 103 – 111.
5. Boulatoff C. and Cyrus T.L., 2022. Improving Student Outcomes in Large Introductory Course, *International Review of Economics Education*, **(**41):p 100247.
6. Roopa A.K., & Hunashyal A.M., 2020. Enhancing Student Learning in Mechanics of Material Course Through Contextual Learning, *Journal of Engineering Education Transformations*, 33(3):p 19 – 25.
7. Gutierrez-Bucheli L., Kidman, G. and Reid, A., 2022. Sustainability in Engineering Education: A Review of Learning Outcomes. *Journal of Cleaner Production*, (330):p 129734.
8. Jadhav M.R., Kakade A.B., Jagtap S.R. and Patil M.S., 2020. Impact Assessment of Outcome Based Approach in Engineering Education in India, *Procedia Computer Science*, (172):p 791–796.
9. Na G., Shankarb S. and Bb S.G., 2022. Structured Evaluation of Laboratory Course Content for Better Attainment of Program Outcomes, *Procedia Computer Science*, (172):p 869–874.
10. Hernandez T., Fallar, R. and Polydorides, A.D., 2021. Outcomes of Remote Pathology Instruction in Student Performance and Course Evaluation, *Academic Pathology*, (8):p 061822.
11. Bosshardt, W. and Chiang, E.P., 2018. Evaluating the Effect of Online Principles Courses on Long-Term Outcomes, *International Review of Economics Education*, (28):p 1-10.
12. Wei X., Saab N. and Admiraa W., 2021. Assessment of Cognitive, Behavioral, And Affective Learning Outcomes in Massive Open Online Courses: A Systematic Literature Review, *Computers & Education*, (163):p 104907.
13. Suhaimi F., 2020. *Perbezaan epidemik, endemik dan pandemic*, Astro Awani, http://www.astroawani.com/berita-malaysia/fahami-perbezaan-epidemik-endemikdan-pandemik-233401, [accessed Jun. 22, 2023].
14. Min H. and Nasir M.K.M., 2020. Self-Regulated Learning in A Massive Open Online Course: A Review of Literature, *European Journal of Interactive Multimedia and Education*, 1(2):p 02007
15. Sufian S.A., Nordin N.A., Tauji S.S.N. and M. Nasir, M.K., 2020. The Impact of Covid-19 on the Malaysian Education System, *International Journal of Academic Research in Progressive Education & Development*, 9(2):p 764-774.
16. Selvam D.R, Xavier, S., Kasinathan, P., Ahmad W.M., Farooq K.M. and Santha K.D.M., 2023. Causes of higher levels of stress among students in higher education who used eLearning platforms during the COVID-19 pandemic, *Journal of King Saud University – Science*, (35):p 102653.
17. Wang D., Adedokun O.A., Millogo O., Madzorera I., Hemler E.C., Workneh F., Mapendo F., Lankoande B., Ismail A., Chukwu A., Assefa N., Abubakari S.W., Lyatuu I., Okpara D., Abdullahi Y.Y., Zabre P., Vuai S., Soura A.B., Smith E.R. and Fawzi W.W., 2023. The Continued Impacts of the COVID-19 Pandemic on Education and Mental Health Among Sub-Saharan African Adolescents, *Journal of Adolescent Health*, (72):p 535-543.
18. Okagbue E.F., Ezeachikulo U.P., Nchekwubemchukwu I.S., Chidiebere, I.E., Kosiso O., Ouattaraa, C. A.T. and Nwigwe E.O., 2023. The effects of Covid-19 pandemic on the education system in Nigeria: The role of competency-based education, *International Journal of Educational Research Open*, (4):p 100219.
19. Recch F., Petherick A., Hinton R., Nagesh R., Furst R. and Goldszmidt R., 2023. Education data needs and challenges for building back from COVID-19, *Epidemics*, (43):p 100673.
20. Isha, S. and Wibawarta, B., 2023. The impact of the COVID-19 pandemic on elementary school education in Japan, *International Journal of Educational Research Open*, (4):p 100239.
21. Akabayashi, H., Taguchi, S. and Zvedelikova M., 2023. Access to and demand for online school education during the COVID-19 pandemic in Japan, *International Journal of Educational Development*, (96):p 102687.
22. Ferrer J., Iglesias E., Blanco-Gutiérrez L. and Estavillo J., 2023. Analyzing the impact of COVID-19 on the grades of university education: A case study with economics students, *Social Sciences & Humanities Open*, (7):p 100428.
23. Imran R., Fatima A., Elbayoumi S.I. and Allil K., 2023. Teaching and learning delivery modes in higher education: Looking back to move forward post-COVID-19 era, *The International Journal of Management Education*, (21):p 100805.
24. Mahajan R., Lim W. M., Kumar, S. and Sareen M., 2023. COVID-19 and management education: From pandemic to endemic, *The International Journal of Management Education*, (21):p 100801.

 DOI: https://doi.org/10.11113/jm.v46.497

25. Abidemi A., Akanni J.O. and Makinde O.D., 2023. A non-linear mathematical model for analysing the impact of COVID-19 disease on higher education in developing countries, *Healthcare Analytics*, (3):p 100193.

DOI: https://doi.org/10.11113/jm.v46.497