



Machine Learning Techniques for Understanding and Enhancing Student Adaptation in the Post-Pandemic Online Learning Environment

*Paras Parashar¹, Randeep Singh², Deepak Chandra Uprety³

^{1,2}IEC University, Baddi, 174103, Solan, Himachal Pradesh, India

³Noida Institute of Engineering and Technology, Greater Noida, Uttar Pradesh, India
pparashar1231@gmail.com, randeepoonia@gmail.com, deepak.glb@gmail.com

Abstract: This research paper presents a complete assessment of current improvements in using machine learning techniques to assess and improve scholar revision in post-pandemic online learning environments. Nowadays, digital education continues to develop, and educators and representatives must escalate how scholars relate, get involved, and adjust to online education. Machine learning provides vigorous tools for analyzing various data sources, including scholars' interaction records, presentation metrics, and commitment designs, providing valued visions into discrete and group learning methods. The analysis examines machine learning platforms such as cataloging, clustering, and analytical demonstration to monitor and calculate student alteration. To expand educational results and student assignment, these methods cover the way for building modified learning pathways, real-time monitoring systems, and modified intrusions. This paper also discusses the task of realizing these replicas, such as scalability, data privacy, and certifying model correctness across unlike enlightening backgrounds. Generally, the result emphasizes the transformative approach of machine learning in building more adaptive, responsive, and operative online learning surroundings.

Keywords: Student Adaptability, Online Education, Machine Learning, Personalized Learning, Digital Divide, Educational Technology.

1. INTRODUCTION

Classroom setting is a crucial factor for shaping students' skills and opportunities and is extremely influenced by the quality of education and the use of the efficiency of students' skills to apply, analyze, combine, and estimate educational content within classroom sites [1]. Assimilating "Information and Communication Technology" (ICT) into education has become important for enhancing it in today's globalized and privatized world [2]. E-learning provides 24/7 access from homes, schools, offices, and other places and plays a vital role in delivering information, concepts, and services across numerous geographic localities. The e-learning implication has been chiefly obvious during the COVID-19 pandemic [3]. To advance educational outcomes, informative approaches are swiftly acclimating to integrate these evolving technologies. E-learning, powered by advanced digital infrastructure, signifies a new instructional model to deliver educational or training content digitally [4]. This e-learning model is influenced by "Information and Communication Technology" (ICT) resources such as computer-based learning, teleconferencing, videoconferencing, emails, live chat, blogs, and social media platforms [5]. To enhance learning experiences, the expansion of "Technology Enhanced Learning" (TEL) goes beyond traditional "Computer Based Learning" (CBL) and "Computer Assisted Instruction" (CAI), covering any educational process [6]. At the time of the COVID-19 pandemic, recent research highlights enhanced the widespread acceptance of online teaching, with millions of beginners appearing in digital learning activities worldwide [7]. E-learning supports diverse instructional approaches, improves student retention rates, and accelerates the learning process [8]. During lockdown, many educational institutions transitioned to online delivery methods, increasing the role of parental involvement in education [9].

The digital transformation of education optimizes online pedagogy and maximizes technological benefits [10]. The epidemic highlighted the necessity of online education as a complementary aspect of traditional education, with projections indicating a significant increase in internet users, emphasizing the growing importance of digital tools in education [11]. Online education revitalizes learning across various domains, facilitating engaging and innovative sessions [12]. Recent advancements in digital tools demonstrate a shift towards student-centered learning models, offering opportunities for scalability, strategic implementation, and integration with traditional methods [13]. This approach supports experimentation, relevance, measurability, and cost-effectiveness, significantly enhancing learning flexibility and reusability of materials [14]. E-learning tools contain a wide range of electronic devices, such as PDAs, televisions, tablets, and smartphones, commonly used in both urban and rural areas [15]. The widespread use of communication platforms like WhatsApp, Facebook, and Instagram, particularly in rural regions, underscores the importance of incorporating these technologies into e-learning systems [16]. Effective implementation of online learning requires adaptability, robust infrastructure, and carefully designed solutions that meet students' digital needs [17]. The pandemic has driven innovation in educational methods, increasing the demands on both students and educators and highlighting the need for governments and higher education institutions to develop comprehensive training programs to foster knowledge enhancement and adaptation to new educational models [18].

II. LITERATURE REVIEW

In the 18th century, the advent of postal courses marked the beginning of distance education, setting the foundation for today's digital learning landscape. However, it was in the latter part of the 20th century, fueled by internet advancements, that the true potential of online education began to emerge [9]. Currently, technical inventions like "high-speed internet" and advanced "learning management systems" (LMS) like Moodle and Canvas now simplify smooth content delivery across digital platforms. These technologies create virtual classrooms that range beyond geographic limits and support content distribution, messaging, valuation, and teamwork [10]. Advances in teaching strategies deeply influence the development of online education. Initially, educationalists planned online education to mimic outdated classrooms, but they soon realized the need for methods specifically tailored for the digital environment. As a result of informative ideas such as constructive and connectivism, highlights of active learning, association, and communal contact have gained encouragement, and plans like gamification, microlearning, and adapted learning have appeared, knowingly enlightening assignment and consequence in online education. The suppleness of online learning is obvious through its wide range of formats, such as online, blended, and hybrid courses, which allow it to meet varied educational needs. Promptly, there are two common courses: Massive Open Online Courses (MOOCs) have extended revealing access by providing excellent content from leading institutes, while micro-credentials and certification courses offer supple learning courses for skill development and proficient progression [11]. Students who lack access to traditional educational resources globally turn to online education. Those students enroll themselves in top institutes notwithstanding time zone or location. Simulation is an advanced technology that imitates real-world circumstances and replies to student communication, which offers an immersive learning experience. Furthermore, learning analytics has grown by integrating data from online learning platforms. With the help of these tools, instructors monitor student commitment, presentation, and conduct for permitting modified sustenance and prospectus alteration [12].

A literature review is a widespread examination of preceding studies within a definite arena, providing an in-depth overview and summary. A literature assessment is a systematic, strong, and repeatable procedure for defining, appraising, and merging the part of already known info. Authors [13] have explained the difference between cMOOCs and xMOOCs programs and highlighted social consciousness as an appreciated context for accepting MOOC courses [14]. Joshi, A., Vinay, M., & Bhaskar, P. (2020) have explained the difficulties tackled by Indian teachers leading work-from-home classes and disclosed contests such as insufficient conveniences and digital illiteracy among teachers [15]. At the time of the pandemic, students' perceptions of online education specified mixed replies, with pleasure prejudiced by factors like network issues and access to technical resources [16]. The application of MOOC courses on the platforms of NPTEL and SWAYAM in India is facing problems related to budget and technical infrastructure [17].

The impact of digital education on the economy was also evaluated, highlighting its role in enhancing employability abilities and submission worldwide [18]. Cultural-Historical-Activity-Theory (CHAT) examines how schools traverse digitalization and emphasizes the part of learning theories in educational transformation [19]. Digitalization's effect on teaching highlights both its benefits and loss, emphasizing the need for stable implementation [20]. India deliberates on cloud education, highlighting its potential to enhance learning flexibility and convenience [21]. Exploration of cMOOCs and xMOOCs highlights the significance of instructional value in online courses [22]. Establishing the transformative potential of tablet-based education shows the efforts made to promote digital literacy [23]. In India, infrastructure issues continue for both government and individuals in spite of the rapid growth of digital education [24].

The influence of digital marketing on online education services is examined, identifying key factors that attract students to digital platforms [25]. The analysis of MOOCs courses highlights the challenges and opportunities they present for students and institutions [26]. The influence of digital promoting strategies on students' perceptions of online education is investigated, showing a significant effect on their decision-making processes [27]. Furthermore, the study stresses the need for a roadmap to address challenges and maximize the potential of digital learning [28]. Assessment of ICT usage in educational settings shows its positive effect on students' learning experiences and outcomes [29]. The trials tackled by educators in adopting online technologies underline the need for comprehensive exercise and support [30]. Likewise, students' perceptions of online courses reveal confidence in their ability to succeed, highlighting the importance of understanding student demand [31]. The quality of knowledge in e-learning environments is assessed, showing students' preference for accurate and relevant content [32]. Additionally, the feasibility of e-learning is emphasized, with evolutionary economics principles highlighting its societal necessity [33]. Several scholarly investigations have delved into the intricate dimensions of student adaptation within online education systems, as evidenced by several research papers. A notable study centered its attention on the analysis of student adaptation during the period of evolution to online education amidst the COVID-19 lockdown. This research provides acute visions of the tasks and alterations tackled by university students pursuing education degrees [38]. The e-learning research accurately appraised the impact of cMOOCs and xMOOCs methods on intellectual knowledge experience. The result of these studies remarked that the trials applied were strangely fruitful [39]. Furthermore, another research work strictly considered the efficiency of an online module planned to tell system thinking concepts to a miscellaneous audience.

Table 1: Literature Review

Year	Title/Study	Key Findings	Methodology	Relevance to Current Study
2013	Educational Data Mining: Assessment of the State of the Art [38]	Tainted the latent of data-mining in education for predicting student performance and improving decision-making processes.	A systematic review of educational data mining procedures and their presentations	Provides foundational insight into using data mining techniques like clustering and classification for student performance analysis
2015	Self-Regulated Knowledge and Theoretical Accomplishment in Online Education: A Meta-Analysis [43]	Found that self-regulated knowledge tactics such as area set, period managing, and metacognitive strategies are critical for success in online learning	Meta-analysis of various self-regulated learning strategies and their impact on academic outcome.	Demonstrates the importance of behavioral indicators in online student success, relevant for adaptation analysis.
2018	Intelligent Tutoring Systems in	Discussed how Intelligent Tutoring	Review of AI and machine learning	Offers insights into adaptive and

	E-Learning: A Review [42].	Systems (ITS) leverage AI and ML to adaptively guide student learning in real-time	methods in e-learning and Intelligent Tutoring Systems (ITS)	personalized learning models, key for assessing student adaptation.
2019	Online Student Engagement and Performance: A Machine Learning Perspective [39]	Found that student engagement metrics such as LMS logins, discussion forum participation, and assignment submissions can predict academic success	Machine learning techniques applied to student interaction data from LMS	Relevant for identifying key behavioral indicators for adaptation and performance prediction in online education
2020	Predicting Student Satisfaction with Online Learning using Data Mining [40].	Emphasized that factors such as interaction quality, timely feedback, and course design influence student satisfaction in online courses.	Applied decision trees and clustering algorithms to predict student satisfaction.	Highlights factors that contribute to successful student adaptation in online learning environments.
2021	An Adaptive Knowledge System Based on Data-Driven Modelling and ML [41]	Proposed an adaptive learning system that personalizes content delivery based on student learning pace and behavior.	Machine learning algorithms (SVM, Decision Trees) used to personalize learning paths.	Provides a personalized approach for improving student adaptation, relevant to the proposed framework
2021	Data-Rich Models for Online Learning Environments: Enhancing Student Success [42]	Proposed using data-rich student models to track engagement and provide adaptive learning experiences	Mixed-methods study utilizing student engagement metrics and machine learning analysis	Supports the idea of integrating multiple data sources to assess and enhance student adaptation in online settings.
2022	Understanding Student Adaptation in Blended Learning Environments [43]	Blended learning environments require students to balance online and offline learning, which impacts adaptation.	Survey and behavioral data analysis using regression models.	Relevant for identifying adaptation patterns that can be applied to fully online learning environments

III. RESEARCH GAPS

Based on the literature review mentioned in Table 1, the research gap acknowledged that Gmail and SWAYAM PRABHA are commonly used by teachers compared to YouTube and Facebook. Researchers suggest that for teachers to effectively use online resources, they require improved computer skills, training, communication, and connectivity with students [34]. Despite students appreciating the opportunity to learn new things through online learning, both teachers and students encounter significant challenges during these classes. The article aims to provide a SWOC (Strength, Weakness, Opportunity, and Challenge) analysis of online learning, with an emphasis on EdTech startups operating during the pandemic and strategies for addressing challenges related to online education. Notable EdTech platforms such as BYJU'S, Unacademy, Zoom Classroom, and Topper have been highlighted as beneficial for students. The SWOT analysis reveals strengths like time flexibility, wide availability, and immediate feedback, whereas weaknesses include technical difficulties, time management issues, lack of physical attention, and frustration. Opportunities noted are the prospect for digital growth, innovation, and the absence of age restrictions. However, challenges such as ICT infrastructure limitations, digital illiteracy, digital divides, and the high cost of technology remain significant obstacles. The analysis suggests a need for readiness, e-learning tools, e-books, and online resources to facilitate adaptation to changing environments [35]. Further, researchers found low awareness among teachers and students regarding MOOC courses like SWAYAM, with no significant gender-based differences. The study concludes that there is a critical need for increased development and facilities to enhance the understanding and accessibility of these courses [36]. Advanced learning proves that participating mobile phones in the training learning procedure introduced a new phase of digital education through mobile applications [37].

IV. CONCLUSION

Machine learning in education highlights its transformative power through several features of the educational background. Machine learning is sure to change various aspects of the school's teaching and learning procedures. Educational investors can achieve deeper visions into student learning procedures and performance by using machine learning algorithms and leading policy changes, modified lesson planning, and more efficient laboratory planning. Moreover, e-learning analytics permits institutes to strictly monitor scholars and offer personalized support to beginner's profiles, academic accomplishment, and all-inclusive growth. Besides classroom activities, the role of machine learning extends to managerial chores such as judging student growth and estimating educational results. All these activities esteem intermission for educationalists but also allow them to focus on revolution and develop attractive learning environments to supply several requirements for scholars. Generally, all these perceptions underline the wide area of machine learning in the field of education. With the help of machine learning techniques, policymakers and instructors continue to recover and attach the skills of machine learning technologies and solve new opportunities for progressing scholars' learning environments.

V. ACKNOWLEDGEMENTS

We would like to express our heartfelt gratitude to IEC University Baddi for providing the resources and support essential for this research. We extend our sincere thanks to our mentors, Dr. Randeep Singh and Dr. Deepak Chandra Uprety, for their invaluable guidance, constructive feedback, and encouragement throughout this study. Special thanks to our colleagues and collaborators for their insightful discussions and technical assistance, which greatly contributed to the quality of this work. Finally, we are grateful to our families and friends for their unwavering support and understanding during this endeavor.

REFERENCES

- [1] Jena, D. P. K. (2020). Impact of pandemic covid. *International journal of current research*, 12(7). DOI: <https://doi.org/10.24941/ijcr.39209.07.2020>
- [2] Dutta, D. A. (2020). Impact of Digital Social Media on Indian Higher Education: Alternative Approaches of Online Learning during COVID-19 Pandemic Crisis. *International Journal of Scientific and Research Publications (IJSRP)*, 10(05), 604–611. <https://doi.org/10.29322/ijsrp.10.05.2020.p10169>
- [3] Mahapatra, a., & Sharma, p. (2021). Education in times of covid-19 pandemic: academic stress and its psychosocial impact on children and adolescents in India. In *international journal of social psychiatry* (vol. 67, issue 4, pp. 397–399). Sage publications ltd. <https://doi.org/10.1177/0020764020961801>
- [4] Gali, Y., & Schechter, C. (2020). NGO involvement in education policy: Principals' voices. *International Journal of Educational Management*, 34(10), 1509-1525.
- [5] Subroto, W. (2021). Prevention acts towards bullying in Indonesian schools: A systematic review. *AL-ISHLAH: Jurnal Pendidikan*, 13(3), 2889-2897.
- [6] Singh, S., Singh, U. S., & Nermend, M. (2022). Decision analysis of e-learning in bridging digital divide for education dissemination. *Procedia Computer Science*, 207, 1970-1980.
- [7] Prajapati, B. (2019). Entrepreneurial intention among business students: The effect of entrepreneurship education. *Westcliff International Journal of Applied Research*, 3(1), 54-67.
- [8] Singh, Swati, & Ranjith, M. (2021). Lockdown and its Impact on Education, Environment and Economy. *Journal of Advances in Education and Philosophy*, 5(4), 116–119. <https://doi.org/10.36348/jaep.2021.v05i04.005>
- [9] Khatri, S. K. (2024). Higher Education in the Digital Era: Exploring the Transformative Effects of Technological Advancements on Higher Education. *Dr. Seema Saxena*, 19(5).
- [10] Sunita, M. L. Education: The 2021 (Post-COVID) Edition.
- [11] Priyadarshini, V., Ahmed, M. S., Sathya, R., Koteeswari, D., & Ragothaman, S. (2023). Direct Test Effect of Disruptive Technology Acceptance Model (DTAM) on Massive Online Open Courses(MOOCs) Learners' Satisfaction. *Indian Journal of Science and Technology*, 16(8), 590-597.
- [12] Subha, S., & Priya, S. B. (2021, November). Comparative analysis of supervised machine learning algorithms for evaluating the performance level of students. In *2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)* (pp. 1-10). IEEE.
- [13] Patel, D. J. M. (2017). Web Based Tools of Technology In Future Teaching Learning Strategies. *International Education & Research Journal [IERJ]*, 3(2).
- [14] Clara, M., & Barbera, E. (2013). Learning online: massive open online courses (MOOCs), connectivism, and cultural psychology. *Distance Education*, 34(1), 129– 136. <https://doi.org/10.1080/01587919.2013.770428>
- [15] Joshi, A., Vinay, M., & Bhaskar, P. (2020). Impact of coronavirus pandemic on the Indian education sector: perspectives of teachers on online teaching and assessments. *Interactive Technology and Smart Education*, 18(2), 205–226. <https://doi.org/10.1108/ITSE-062020-0087>
- [16] Kumar, R. (2020). Students' Perception towards Digitization of Education after Covid- 19: A Survey. In *International Journal of Engineering, Science, Technology and Innovation (IJESTI) IJESTI* (Vol. 1, Issue 1). www.ijesti.com
- [17] Chauhan, J. (2017). An Overview of MOOC in India. *International Journal of Computer Trends and Technology*, 49. <http://www.ijctjournal.org>
- [18] Seethal, K., Menaka, B., & Scholar, R. (2019). Digitalization Of Education In 21 ST Century: A Boon or Bane. <https://doi.org/10.18231/2454-9150.2019.0436>
- [19] Pettersson, F. (2021). Understanding digitalization and educational change in school by means of activity theory and the levels of learning concept. *Education and Information Technologies*, 26(1), 187–204. <https://doi.org/10.1007/s10639-020-10239-8>

- [20] Frolova, E. V. (2020). Digitalization of Education in Modern Scientific Discourse: New Trends and Risks Analysis. *European Journal of Contemporary Education*, 9(2). <https://doi.org/10.13187/ejced.2020.2.313>
- [21] Jha, P. N., & Shenoy, P. V. (2016). Digitization of Indian Education Process: A Hope or Hype. *IOSR Journal of Business and Management*, 18(10), 131–139. <https://doi.org/10.9790/487x-181003131139>
- [22] Margaryan, a., bianco, m., & little john, a. (2015). Instructional quality of massive open online courses (moocs) Computers and education, 80, 77–83. <https://doi.org/10.1016/j.compedu.2014.08.005>
- [23] Nedungadi, P. P., Menon, R., Gutjahr, G., Erickson, L., & Raman, R. (2018). Towards an inclusive digital literacy framework for digital India. *Education and Training*, 60(6), 516– 528. <https://doi.org/10.1108/ET-03-2018-0061>
- [24] Rampravesh Gond, M., & Gupta, R. (2017). A Study On Digital Education In India: Scope And Challenges Of An Indian Society (Vol. 2, Issue 3). www.anveshanaindia.com
- [25] Singh, S. (2017). Digital Marketing in Online Education Services. *International Journal of Online Marketing*, 7(3), 20–29. <https://doi.org/10.4018/ijom.2017070102>
- [26] Kaplan, A. M., & Haenlein, M. (2016). Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizons*, 59(4), 441– 450. <https://doi.org/10.1016/j.bushor.2016.03.008>
- [27] Basha, A. (2019). A study on effective digital marketing strategy in education sector at bangalore city. *International Journal of Research and Analytical Reviews (IJRAR)* www.ijrar.org, 161.
- [28] Bordoloi, R., Das, P., & Das, K. (2021). Perception towards online/blended learning at the time of Covid-19 pandemic: academic analytics in the Indian context. *Asian Association of Open Universities Journal*, 16(1), 41–60. <https://doi.org/10.1108/AAOUJ-09-2020-0079>
- [29] Tyagi, D. R., & Singh, R. (2015). Status of ICT in Education and Support of Govt. Of India. *International Journal of Engineering Research and General Science*, 3(1). www.ijergs.org
- [30] Jain, S., Lall, M., & Singh, A. (2021). Teachers' Voices on the Impact of COVID-19 on School Education: Are Ed-Tech Companies Really the Panacea? *Contemporary Education Dialogue*, 18(1), 58–89. <https://doi.org/10.1177/0973184920976433>
- [31] Martin, f., stamper, b., & flowers, c. (2020). Examining student perception of readiness for online learning: importance and confidence. *Online learning journal*, 24(2), 38–58. <https://doi.org/10.24059/olj.v24i2.2053>
- [32] Waheed, M., Kaur, K., & Qazi, A. (2016). Students' perspective on knowledge quality in eLearning context: a qualitative assessment. *Internet Research*, 26(1), 120–145. <https://doi.org/10.1108/IntR-08-2014-0199>
- [33] Raja, R., & Naga Subramani, P. C. (2018). Recent Trend of Teaching Methods in Education" Organized by Sri Sai Bharath College of Education Dindigul-624710. *India Journal of Applied and Advanced Research*, 2018(3), 33–35. <https://doi.org/10.21839/jaar.2018.v3S1.165>
- [34] Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open*, 1. <https://doi.org/10.1016/j.ijedro.2020.100012>
- [35] Dhawan, S. (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. *Journal of Educational Technology Systems*, 49(1), 5–22. <https://doi.org/10.1177/0047239520934018>
- [36] Sivakumar, D. R. (2019). Awareness of MOOCs-SWAYAM among Student - Teacher. *English-Marathi, Quarterly, Sanshodhan Chetana*, 8(1).
- [37] Sunitha, R., & Elina, S. (2020). A Study on Mobile Applications in Education (Vol. 11, Issue 1).

- [38] Romero, C., & Ventura, S. (2013). Educational Data Mining: A Review of the State of the Art. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, 43(6), 982–1002.
- [39] Xie, J., Wang, F., Liu, X., & Xu, X. (2019). Online Student Engagement and Performance: A Machine Learning Perspective. *IEEE Access*, 7, 165806–165817.
- [40] Hew, K. F., Hu, X., Qiao, C., & Tang, Y. (2020). Predicting Student Satisfaction with Online Learning using Data Mining Approaches. *Journal of Educational Technology & Society*, 23(2), 120–132.
- [41] Zhang, Y., Zhao, H., Li, J., & Su, X. (2021). An Adaptive Learning System Based on Data-Driven Modeling and Machine Learning. *IEEE Transactions on Learning Technologies*, 14(1), 85–96.
- [42] Alkhatlan, A., & Kalita, J. (2018). Intelligent Tutoring Systems: A Comprehensive Historical Survey with Recent Developments. *International Journal of Computer Applications*, 179(35), 26–32.
- [43] Broadbent, J., & Poon, W. L. (2015). Self-Regulated Learning Strategies & Academic Achievement in Online Education: A Meta-Analysis. *Internet and Higher Education*, 27, 1–13.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

