

Online learning effect analysis based on machine learning

Junyu Su^a, Fengling Wang^{*ab}, Wenjian Liu^a, Chiyu Shi^a

^aInstitute of Data Science, City University of Macau, Macao 999078, China; ^bSchool of Artificial Intelligence, Hezhou University, Hezhou 542899, Guangxi, China

ABSTRACT

Online learning has grown in popularity due to the advancement of Internet technology, and how to accurately assess its efficacy has emerged as a major challenge. Online learning provides advantages and benefits in terms of enhancing people's learning effectiveness and cognitive approach, but it also faces numerous obstacles as a new learning technique and educational model. To increase the efficacy of online learning, we assess and investigate the existing state, shortcomings, learning effects, and behavioral evaluation of online learning in this research.

Keywords: Machine learning, online learning, effect analysis, research status

1. INTRODUCTION

The use of network technology in education is expanding quickly due to the rapid growth of modern information technology, and research on the impact of online learning based on machine learning has emerged as a new hot topic. By employing a genetic algorithm, Lang and Fan (2019)¹ anticipate online learning outcomes and use learning vector quantization to categorize data on online learning behavior. Using data and models with machine learning expertise, Sun and Feng (2019)² investigated the primary, secondary, and irrelevant factors that affect online academic accomplishment. North Minzu University was used as an illustration by Zhao et al. (2019)³ as they investigated the primary influencing aspects of online learning efficiency. Guo and Liu (2018)⁴ looked into the relationship between the effectiveness of online learning and student conduct. Using data mining, the association between adult learners' online learning habits and learning efficacy was further examined by Chen Yuanyuan et al. (2019)⁵. Due to the intricacy and randomness of the online learning process, researchers have various conclusions on the factors that influence online learning efficacy.

Online learning has grown in popularity due to the growth of the Internet and mobile networks, including MOOCs and micro-courses. The number of online learning users has increased greatly, but the popularity has also brought about many problems. For example, the quality of online learning platforms varies, the amount of online learning resources is in quantity rather than high quality, online learning is not effective for learners, and online learning platforms are not intelligent enough to provide feedback as well as to select the right learning platform and learning resources for individual needs. How to use machine learning to analyze online learning behavior and learning effect, increase learners' interest in learning, to improve learners' online learning effect is a hot topic in current research⁶.

2. RELATED REVIEW

2.1 Machine learning

Machine learning as a multidisciplinary interdisciplinary subject, involves multiple disciplines such as statistics and probability theory and is based on research in statistics, probability theory, computer vision, and data mining. Machine learning is imitating human learning models, based on human learning models, and transferring large amounts of data to machines for simulation and drawing relevant conclusions by induction. Machine learning techniques fall into three categories: supervised learning, unsupervised learning, and reinforcement learning.

2.2 Online learning

Professor Ding (2002)⁷, a pioneer in open and distance education research in China, describes online learning as the third generation of distance education built on two-way interactive electronic information technologies (based on e-technology), and computer technology is the most important factor of distance practice. Scholars such as Huang (2012)⁸ have a broad definition of online learning, which refers to the learning method of accessing its contents through computers. In short,

* wfl232983@163.com

scholars' understanding of the definition of online learning includes the following aspects: online learning is accessing learning materials through the Internet. Online learning is a cutting-edge approach to instructing distant learners using the Internet as a medium. Besides, Online learning has the characteristics of being learner-centered, distributed, web-based, flexible, and knowledge-building.

Online learning, also known as e-learning, is a tool that emerged in the context of the rapid development of 'Internet + education', which refers to the learning activities of learners in a networked environment with the help of rich and shared online learning resources. It is a new method of teaching, learning, and management in virtual classrooms through a computer network, smartphones and wireless, developed mainly by independent and collaborative learning⁹.

3. ANALYSIS AND RESEARCH ON EVALUATION OF ONLINE LEARNING EFFECT

3.1 Main features of online learning effect evaluation

3.1.1. Whole Process Learning. Traditional classroom teaching tends to be one-off, with an assessment based mainly on student performance and academic achievement, such as attendance, class grades, final exam grades, etc. Students listen to the teacher's lectures in class, but they also expect to continue to listen afterward. This is difficult and can cause problems such as classroom decisions on grades and uneven student levels. Online learning has the advantages of 'before class, during class, and after class. The teacher can not only teach in a traditional classroom or live online but can also record the content on video or create slides for uploading. Access to online learning platforms before and after class will undoubtedly provide students with learning opportunities, a lot of free learning sources, and sufficient learning space¹⁰.

3.1.2. Complexity of Component Indicators and Difficulty in Determining Weighting Ratios. Traditional teaching is based on classroom teaching with few evaluation indicators, mainly focusing on learning attitude and learning effect evaluation. The evaluation indicators mainly include attendance, classroom performance, and post-class assignments, and final exams. The operation is relatively simple and easy to operate, but the indicators to be considered in online learning effectiveness evaluation are relatively more complex¹¹. In addition to considering the learning attitude and learning performance involved in the evaluation of traditional classroom teaching, the learning process and learning ability must also be fully considered, such as the number of times of logging into the online learning platform, the length of time spent on learning the courseware, and the number of times of downloading teaching resources¹².

3.1.3. Meet Individual Needs. From the perspective of teachers' teaching, an online learning platform allows for real-time teaching and the uploading of lecture videos, courseware, assignments, and other contents of the course. When choosing teaching methods, they can choose classroom teaching or online live teaching, which can also be used for the selection of learning effectiveness evaluation indicators to meet more needs of teachers. For example, if teachers want to track students' after-class learning, they can check students' online learning platform login time, study time, exercise completion, etc. From the perspective of learning, students can participate in classroom learning on-site, but if they can't understand the knowledge in class or miss class due to accidents and can't keep up with the learning progress, they can learn again by watching the teacher's teaching videos and courseware. Online learning extends the spatial and temporal scope of learning to some extent¹³.

3.2 Current status of research on online learning effect evaluation

Effectively evaluating the learning effect of online learning can fairly, comprehensively, and objectively assess the quality of students' learning and better organize the use of teaching resources. With the popularity and promotion of online learning, many researchers have proposed many good evaluation methods, and the development of online learning evaluation research has become a current hot spot. For example, Professor Zhou¹⁴, a well-known Chinese scholar, first introduced the BP algorithm into online learning evaluation in 2003. In 2008, A fuzzy comprehensive evaluation method of network learning based on entropy is proposed by Zheng¹⁵. After that, Jared and Grace¹⁶ proposed a triangular model using activity theory as an evaluation method for online learning in 2011. In the same year, Yangman¹⁷ proposed a study on a learning ability evaluation model based on web-based online learning. In 2014, Ma¹⁸ proposed a review of online learning evaluation research based on peer assessment. Lu et al.¹⁹ proposed an online evaluation model designed using an improved LMBP algorithm in 2016. Two years later, Wang and Mao²⁰ used multiple regression analysis to determine the evaluation factors of students' learning effectiveness in online courses and constructed an evaluation model. In 2020, Yan²¹ proposed a study on the evaluation of nursing students' online learning effectiveness. After consulting a large number of papers, it is found that there are many academic achievements of online learning effect evaluation, which are worthy of research and reference, but most of them are biased towards theoretical research such as algorithms, and

research on online learning effect evaluation model is relatively few, most of them are still traditional classroom teaching evaluation.

3.3 Insufficiency of the existing online learning effect evaluation model

The existing evaluation of the online learning effect in China has the following main deficiencies. First, the evaluation system is still based on traditional classroom teaching evaluation. Due to the technical nature and insufficient functions of the online learning effect evaluation module, it makes some teachers are unable to conduct online learning evaluation well and cannot be integrated into online learning. Some colleges and universities use online learning platforms, but the functions are complicated, the effect evaluation cannot be incorporated into the teaching evaluation system on time. Second, the evaluation method is single. In the colleges and universities that lack online learning on the platform, classroom teachers can only conduct traditional classroom teaching evaluation, while colleges and universities that use online learning platforms either have a low weighting of online learning evaluation or single evaluation indexes. For example, they only evaluate the completion of assignments in the online learning platform, without being affected by factors such as the length of students' online learning. Third, evaluation indicators are not comprehensive. Some teachers carry out the online evaluation of learning effects considering fewer evaluation indicators, such as only considering the completion of assignments in the online learning platform, emphasizing evaluation results rather than process evaluation. Teachers not only need to focus on the evaluation of students' learning attitudes and academic performance, but also focusing on the evaluation of learning innovation and learning ability improvement, such as the quality of communication and interaction in assignments²².

Through research and analysis, it is found that Chinese learners have the following shortcomings in online learning.

3.3.1 Inattentiveness and Fragmented Learning of Students. At present, there are many online learning platforms with complete functions and convenient operations, and there are also some large-scale online learning platforms that push advertising games, teachers cannot organize online teaching successfully. Also, assignments are not feedback in time, teaching videos are not uploaded in time, and learning effect evaluation is not carried out in time, which all affects students' enthusiasm for online learning²³⁻²⁶.

3.3.2 The Evaluation Model Is Traditional, the Means Is Single, and the Evaluation System Is Not Scientific and Rational Enough. Various online learning platforms have their advantages and disadvantages, and it is difficult to meet the individual needs of teachers and students. But in general, the use of online learning platforms can provide a seamless, continuous, and repetitive learning space for teachers and students, and also provide a new perspective for teachers to carry out teaching evaluations and be able to track and grasp students' learning after class. There are many problems with online learning at present, in addition to the mentioned problems such as platform technology, there are also problems such as lack of attention by classroom teachers, loose management of online learning, failure to carry out the timely evaluation of online learning effects, and untimely have feedback of assignments, such that the online learning platform is dispensable²⁷⁻³⁰.

3.3.3 Low Motivation of Teachers and Students to Participate. In China, there are not many large-scale online learning platforms that register to use and conduct online teaching. A few colleges and universities conduct online learning through Chinese University City, but only upload courseware to the Internet for students to learn, without providing data such as lecture videos. There are many reasons for this situation, mainly including some online learning platforms with complex and incomplete functions, teachers and students who are unfamiliar with the use of online platforms, and some online learning platforms that require payment³¹⁻³³.

3.4 Research on the evaluation index system of online learning effectiveness

The evaluation of online learning effectiveness is different from traditional learning effectiveness evaluation since online learning pays more attention to the learning status of learners and the ease of the learning process. There are two main modes of learning effectiveness evaluation of online learning, summative evaluation and formative evaluation^{34,35}. Summative evaluation is mainly the final evaluation of learners through online learning. For example, through tests and questionnaires. The formative evaluation mainly revolves around the evaluation methods of teacher evaluation, peer evaluation, and self-evaluation³⁶. The formative evaluation looks at course learning, homework completion, student activities, learner satisfaction, feedback, and so on.

Table 1 lists the learning effect evaluation indicators of online learning.

When teachers teach online, they must evaluate online learning promptly, correct online assignments, respond to students' information and questions, carry out online teacher-student interaction and other communication activities. Also, timely export relevant platforms data for online learning, combining the number of times students log on to online learning platforms, the length of learning courseware, the submission time of assignments, the completion of exercises to evaluation. Study in the online learning platform is an important part of the course evaluation, from 'before class—during class—after class' to the multi-dimensional evaluation of online learning effects, such as 'teacher with student-student-platform', which is more conducive for teachers to know the effect of students' online learning in real-time, and improve the efficiency and quality of learning.

Table 1. Evaluation index of learning effect of online learning.

Evaluation index	Definition
Course	Whether the learner completes the course study and the frequency of study
Operation	Complete homework on time, peer evaluation, teacher evaluation, self-evaluation
Activity	Participation of interest groups, participation of group activities, participation of course activities
Satisfaction	Evaluation of learning support or service, willingness to continue system use, goodwill, sense of gain, sense of accomplishment, etc.
Feedback	Teacher feedback, peer feedback, self-reflection

This essay aims to establish a more scientific and reasonable evaluation system for online learning, which focuses not only on the evaluation of results but also on the evaluation of the learning process. Formative evaluation and comprehensive examination of the online learning process in the middle of the learning attitude, learning process, learning resources, learning ability, learning performance, from 'before class—during class—after class' and other multi-dimensional assessments to evaluate the effectiveness of online learning.

According to the current teaching situation and the actual situation, it is planned to determine the indicators of the online learning evaluation system consisting of five modules: learning attitude, learning resources, learning process, learning ability, and learning performance. The specific indicators and reference scores are shown in Table 2.

Table 2. Specific indicators and reference score Table.

Learning attitude (20 points)	Learning resources (10 points)	Learning process (10 points)	Learning ability (10 points)	Academic performance (50 points)
(1) Number and time of logins to the platform, and roll call for live lectures. (2) Duration of watching teaching videos and courseware, etc. (3) Participation in discussions. (4) The number and time of assignment submission. (5) Submission time for completing course design and exercises	(1) Number of views of teaching videos, courseware, handouts, homework, etc. (2) The number of uploads and downloads of homework, course design, etc. (3) Types and times of downloading teaching resources.	(1) The number of questions and answers. (2) Number and duration of online discussions. (3) Self-evaluation; (4) The completion of phased learning works.	(1) The quality of opinions expressed. (2) Relevance of content in active questioning (3) The quality of answering questions. (4) Innovative problem solving. (5) Curriculum design, exercises and answers are innovative.	(1) Yijie test results. (2) Results of random test in class. (3) Assignments and work results. (4) Course design achievements. (5) Final test or performance.

The evaluation score of each first-level indicator is preliminarily determined: 20 points for learning attitude, 10 points for the learning process, learning resources and learning ability, and 50 points for academic performance. The total score is 100 points. In principle, the “final test score” of the secondary index should not be less than 30 points to ensure the importance of the final test. Teachers can appropriately increase the weight of academic performance module scores and final exam scores according to the actual teaching situation. If both online and offline learning is carried out at the same time, with classroom teaching as the main body and online learning as a supplement, teachers can adjust the scores and weights of the first and second indicators appropriately, and increase or decrease them according to their functions. The content of the first and second levels can be subtracted from the situation of the online learning platform. Teachers can dynamically analyze online learning effect evaluation indicators according to actual needs to stimulate the interest and autonomy of online learning.

To improve the learning effect and quality of online students, the index content of the online learning effect evaluation system focuses on the teacher’s evaluation of students’ online learning effect. Companies can make dynamic adjustments based on the use of online learning platforms, the courses offered by universities, and the personal needs of teachers and students, and continuously improve the functions of the learning effect evaluation module of the online learning platform to lay the foundation for the development of the platform to better evaluate the online learning effect.

4. CONCLUSIONS

With the application and promotion of online learning, how to improve the effectiveness of online learning has become a research hotspot. By studying and analyzing the current situation and existing problems of students’ online learning, this study uses technical methods related to machine learning to effectively improve the effectiveness of online learning, thus improving learning efficiency and learning quality. Through the analysis of online learning behaviors, it was found that behaviors such as homework completion rate, video completion rate, and orderly video viewing have significant positive effects on the final online learning outcomes. Some online learning behaviors can seriously affect online learning effectiveness and have negative effects. Therefore, how instructors guide learners to generate virtuous online learning behaviors and avoid or reduce undesirable online learning behaviors during the online learning process will play a crucial role in the overall course effectiveness. In the future, it will be important to focus on and develop the overall design of online learning for teachers and procedural guidance for learners.

REFERENCES

- [1] Lang, B. and Fan, Y. N., “Online learning performance prediction using learning vectorized sample classification,” *Computer System Applications* 28(03), 215-222 (2019).
- [2] Faqin, S. and Rui, F., “Research on influencing factors of online academic achievement based on learning analysis,” *China Audio-visual Education* (03), 48-54 (2019).
- [3] Zhao, X. F., Li, Q. L. and Liang, C. M., “Analysis of the influencing factors of the learning effect of the online learning platform: Taking the Northern University for Nationalities as an example, the analysis of the influencing factors of the learning effect of the online learning platform,” *Think Tank Times* (03), 165+172 (2019).
- [4] Guo, F. X. and Liu, Q., “Research on the correlation between online learning behavior and learning effect—The practice of flipped classroom teaching based on blackboard,” *Higher Education of Sciences* (01), 8-13 (2018).
- [5] Chen, Y. Y., Liu, S. F., Dong, K., Chen, Y. Y. and Song, Y., “Analysis of online learning behavior and learning effect of adult learners based on data mining,” *Journal of Anhui Radio and Television University* (01), 38-42 (2019).
- [6] Li, L. and Liu, Y. Y., “Research on online learning adaptability and learning effect of college students: Based on data from 1698 questionnaire samples,” *Journal of Changji University* (03), 100-105 (2020).
- [7] Ding, X. F., “E-learning and blended education,” *China Distance Education* (12), 66 (2004).
- [8] Huang, R. H., Zheng, L. Q. and Yang, J. F., “Open learning quality framework in the perspective of information learning,” *Modern Distance Education Research* (06), 10-17 (2012).
- [9] Guo, Q. R., “The current situation and development of online learning for college students under the background of “Internet +”,” *Food Research and Development* 41(18), 240 (2020).
- [10] Li, Z. H., Zhang, Z. L. and Liu, H., “Research on online learning investment evaluation method based on model integration,” *China Distance Education* (10), 9-16+60 (2020).
- [11] Manzano, J. M., Muñoz de la Peña, D. and Calliess, J., “Online learning constrained model predictive control based on double prediction,” *International Journal of Robust and Nonlinear Control* 31(18), 8813-8829 (2021).

- [12] Asim, S., Pedro, C., Alex, G., Kartik, K., Mostafa, M., Jonathon, F., Devesh, W., Susu, X., Adrian, G., Pei, Z., Aurélio, C. and Hae, Y. N., "O-MedAL: Online active deep learning for medical image analysis," *Mining and Knowledge Discovery* 10(4), 1-15 (2020).
- [13] Chen, J. Y., Fang, H., Lin, X., Zheng, H. B., Yang, D. Y. and Zhou, X., "Personalized learning recommendation based on online learning behavior analysis," *Computer Science* 45(S2), 422-426+452 (2018).
- [14] Zhou, X. J. and Liu, Y. Q., "Educational evaluation expert evaluation research based on artificial neural network BP algorithm," *Quantitative Economics and Technical Economics Research* (11), 40-44 (2003).
- [15] Zheng, X. W. and Yu, H. B., "Entropy-based fuzzy comprehensive evaluation method for network learning," *Computer Engineering and Design* (23), 6149-6151 (2008).
- [16] Jared, K. and Grace, O., "Fostering meaningful student learning through constructivist pedagogy and technology integration," *International Journal of Information and Communication Technology Education (IJICTE)* 7(4), 23-28 (2011).
- [17] Yang, M., Gou, X. R. and Li, J. W., "Research on learning ability evaluation model based on online learning," *Journal of Beijing University of Posts and Telecommunications (Social Science Edition)* 13(01), 13-19 (2011).
- [18] Ma, Z. Q., Wang, Y. C., Yue, Y. Z. and Du, H. Y., "Research on online learning behavior model from the perspective of learning analysis," *Modern Distance Education* (06), 35-44 (2019).
- [19] Lu, Y., Chen, J. Y., Xie, J., Chen, H. M. and Fan, X. M., "Research on online learning evaluation model based on LMBP algorithm," *China Distance Education* (03), 28-32+80 (2016).
- [20] Wang, T. T. and Mao, C. L., "Study on the evaluation of online course learning effect based on learning analysis," *China Adult Education* (17), 93-96 (2018).
- [21] Yan, S. J., "Research on the status, problems and countermeasures of online learning for five-year vocational nursing students," *Computer Knowledge and Technology* 16(04), 119-120 (2020).
- [22] Nathan, M., Muhammad, I. and Douglas, A. T., "Ensemble-based online machine learning algorithms for network intrusion detection systems using streaming data," *Information* 11(6), 1-13 (2020).
- [23] Hu, X. Y., Xu, H. Y. and Chen, Z. X., "An empirical study on the relationship between learners' information literacy, online learning input and learning performance," *China Audio-visual Education* (03), 77-84 (2020).
- [24] Zhang, X. L., Huang, Z. Z. and Li, M. L., "An empirical study on the "interactive learning" experience of online learners and its impact on learning effects," *Educational Research of Tsinghua University* 38(02), 117-124 (2017).
- [25] Saad, M., Moamar, S. M. and Abdelhamid, B., "Online active learning for human activity recognition from sensory data streams," *Neurocomputing* (390), 341-358 (2020).
- [26] Said, N., Muhammad, A. M. and Abdul, M. M., "Machine learning based on-line prediction of soil organic carbon after removal of soil moisture effect," *Remote Sensing* 12(8), 1-19 (2020).
- [27] Stephan, R., Steven, V. V. and Matthias, P., "Power prediction for electric vehicles using online machine learning," *Engineering Applications of Artificial Intelligence* (87), 1-11 (2020).
- [28] Villar, J. R., de la Cal, E., Fañez, M., González, V. M. and Sedano, J., "User-centered fall detection using supervised, on-line learning and transfer learning," *Progress in Artificial Intelligence* 8(4), 453-474 (2019).
- [29] Harrell, I. I. and Bower, B. L., "Student characteristics that predict persistence in community college online courses," *American Journal of Distance Education* 5(3), 178-191 (2011).
- [30] Pedro, M. O. Z. S., Baker, R. S. J. D. and Heffernan, N. T., "Predicting college enrollment from student interaction with an intelligent tutoring system in middle school," *Proceedings of the 6th International Conference on Educational Data Mining*, 177-184 (2013).
- [31] Park, J. H. and Choi, H. J., "Factors influencing adult learners' decision to drop out or persist in online learning," *Educational Technology & Society* 12(4), 207-217 (2009).
- [32] Li, Y. C., Wang, X. H. and Zhang, Y. Y., "Research on transformer fault diagnosis based on online sequential extreme learning machine," *Recent Advances in Electrical & Electronic Engineering* 12(5), 408-413 (2019).
- [33] Reuven, C. and Yuval, N., "Cardinality estimation in a virtualized network device using online machine learning," *IEEE/ACM Transactions on Networking (TON)* 27(5), 2098-2110 (2019).
- [34] Toru, S., Takahiko, K., Hiroto, G. and Yasuo, A., "Interactive online machine learning approach for activity-travel survey," *Transportation Research Part B* (123), 362-373 (2019).
- [35] Anonymous, "Online education affordable, convenient and flexible," *Industrial Heating* 87(9), 1-13 (2019).
- [36] Armin, W., Karsten, S. and Frank, F., "Learning to argue online: Scripted groups surpass individuals (unscripted groups do not)," *Computers in Human Behavior* 26(4), 506-515 (2009).