Online-Journals.org

iJET International Journal of Emerging Technologies in Learning

iJET | eISSN: 1863-0383 | Vol. 18 No. 16 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijet.v18i16.42297

PAPER

Influence of Learning Intervention on Online Learners' Performance

Limin Ren(✉), Kelu Fu, Ruifeng Cao

College of Traffic Engineering, Huanghe Jiaotong University, Jiaozuo, China

2016082805@zjtu.edu.cn

ABSTRACT

With the expansion of the online learning scale and the rapid development of learning analysis techniques, learning systems can completely record learners' online learning behavior. What types of learning intervention measures can influence learning performance? How is the intervention working? The above questions are the focus of online courses and emphasize improving the online learning effect. In this research, 96 undergraduates (Classes 1 and 2, Grade 2) majoring in civil engineering and enrolled in the Engineering Surveying online course at the College of Transportation Engineering, Huanghe Jiaotong University, Henan Province, were selected as the research objects and randomly divided into two groups (the experimental group (N = 48) and the control group (N = 48)). Then, conducted a 15-week sustained intervention study through quasi-experimental research, and verified the effectiveness of different types of intervention measures on the learners' learning performance. Next, a one-way analysis of variance was conducted, based on the pretesting of the performance data, the quality of online discussion posts, the effective learning duration, and the online final test results. Research results showed no obvious differences between the experimental group and control group in the online final test results from the previous semester ($P = 0.347$). The online learners' learning performance was influenced by three aspects of the learning intervention, that is, apparent differences in the posting quality in the learning prompt intervention ($T = 8.23$, $P < 0.01$), the online learning duration in the process monitoring intervention ($T = 23.19$, $P < 0.01$), and the online final test results in the achievement incentive intervention ($T = 6.08$, $P < 0.01$). The research results have an important reference value for implementing intervention strategies in the online learning environment, judging the effectiveness of such strategies according to curve changes in performance, and using the mass data of learners recorded by online learning platforms.

KEYWORDS

learning intervention, online learning, learning performance, one-way variance test

Ren, L., Fu, K., Cao, R. (2023). Influence of Learning Intervention on Online Learners' Performance. *International Journal of Emerging Technologies in Learning (iJET)*, 18(16), pp. 198–209. https://doi.org/10.3991/ijet.v18i16.42297

Article submitted 2023-05-14. Resubmitted 2023-06-15. Final acceptance 2023-06-15. Final version published as submitted by the authors.

1 INTRODUCTION

With the development and popularization of technology, the Internet's penetration into society has affected people's daily lives and ways of learning. In the Internet age, the importance of online learning for learners is self-evident. Research on and the use of online learning are of considerable practical significance to the innovation of traditional educational forms and learning and thinking methods in the network age. The appearance of learning technology in the classroom has changed students' traditional learning styles and provided them with possibilities to overcome space-time restrictions and carry out learning activities. Online learning, a new way of learning, is realized through network teaching and learning activities and other digital content in the learning environment. Online learning can change not only the leading role of teachers and the teacher-student relationship in the traditional learning environment but also the teaching structure and educational essence. In the process of traditional online learning, teachers typically use certain summative evaluation methods to measure students' academic performance, ignoring the importance of learning intervention measures in the process. The rapid development of online courses encourages learners to fully utilize their fragmented time to meet their personalized learning needs. Simultaneously, it prompts educators to shift from a traditional "teaching centered" approach to a "learning-centered," one. This shift involves paying considerable attention to the development of students' critical thinking and higher-order thinking abilities. As a result, online courses under the "Internet + Education" model are advancing and experiencing new developments.

Online courses impose extremely high requirements on learners' autonomous learning abilities. As the leader in online courses, teachers provide students with holistic learning services, and students learn and explore the provided knowledge independently with the help of the learning management platform to enhance their understanding of the knowledge and improve their learning efficiency. Compared with students in the traditional face-to-face learning environment, students in the online learning environment expect a higher degree of teaching and social interaction. Therefore, teachers must help students in building their learning scaffolding and actively engage with them to intervene promptly and provide feedback to strengthen their learning process. In view of students' irregular learning behaviors, it is crucial to accurately evaluate their learning level using dynamic learning data from learning management platforms to implement accurate learning intervention measures, provide guidance, and help them design personalized learning schemes. Online learning interventions can help students increase their learning enthusiasm, identify their shortcomings, adjust their learning status, realize personalized learning, improve their learning performance, promote the success of online courses, and improve the teaching quality of online courses. Online learning management platforms can record learners' proper understanding of knowledge, accurately identify weak knowledge based on the learning data, and give correct guidance and suggestions to learners. Learners' degree of knowledge mastery can be accurately predicted based on their curriculum resource browsing history and participation in learning, which enables the personalized content knowledge with different difficulty levels. At the same time, personalized learning programs can be customized according to students' learning interests and abilities. The primary goal of learning intervention is to guide learners effectively through the learning process. Learning intervention in the online learning environment embodies timely and effective feedback and intervention measures for students to acquire new information. Specifically, intervention measures target learners' academic risks to improve their learning performance.

2 LITERATURE REVIEW

In the process of online learning, obvious uncertainties in online learning performance exist owing to learners' basic level, difficulty in the discussion activity design, teachers' teaching level, the rationality of curriculum resources, and students' demand for courses. Thus, considering learning intervention measures is necessary. Learning intervention has become an important component of online education and teaching. The research data on online learning interventions primarily collected through questionnaires, interviews, and online learning management platforms, subsequently used to design relevant intervention measures. Regarding the influence of learning intervention on online learning, Pei, L., et al. [1] adopted a random effect model for comprehensive analysis and believed that online learning intervention has advantages in improving students' knowledge and skills; thus, it can be considered as a potential undergraduate medical teaching method. The research results of Bardach, L., et al. [2] showed that, compared with the control group, both online intervention measures have a significant positive impact on cognitive classroom preparation and self-efficacy, thereby proving the potential of easy-to-implement online intervention measures in improving self-efficacy and classroom preparation. Liu, M., et al. [3] pointed out that adaptive learning interventions can help bridge the knowledge gap in chemistry and emphasized the importance of instructional design in adaptive learning. Fernandez-Rio, J., et al. [4] analyzed the influence of cooperative learning intervention on students' motivation and showed that continuous cooperative learning intervention can improve the intrinsic motivation and recognition adjustment of secondary education students. Meanwhile, Forneris, S. G., et al. [5] demonstrated that situational learning interventions can improve the critical thinking of clinical learners in nursing education. Kiger, D., et al. [6] analyzed the influence of a nine-week mobile learning intervention on students' learning outcomes and showed that the students performed better than the control group in a multiplication test after the intervention. Rosenblatt, J. L., et al. [7] indicated that in the transition stage from primary school to junior high school students' GPA scores drop significantly. In a classroom with high intervention, the decline in the students' GPA during the transition period is less than that in the GPA of the students in the classroom with low intervention. Morris, P., et al. [8] verified the hypothesis that children's learning environments can be improved through social and emotional learning (SEL) intervention, which can improve teachers' ability to solve children's behavioral problems and provide a positive emotional atmosphere in the classroom. Cramer, K. M., et al. [9] examined the flexibility of students' self-reporting and internalization of social emotions to determine the intervention effect of a culturally adaptive SEL program and showed that statistical self-reporting flexibility increases significantly immediately after the intervention. Chen, Z., et al. [10] revealed that online learning interventions can motivate students to actively participate in online learning activities and get high marks on all their tasks, tests, and examinations. According to Rowe, F. A., et al. [11], the influence of self-regulated learning interventions on students' learning achievements in the online learning environment indicates that support for self-regulated learning can significantly improve academic performance. Palaniappan, K., et al. [12] observed that after a gamification learning intervention, the learners' academic performance improved significantly, and gamification strategies used in the online learning environment have a positive impact on learners' autonomous learning. Yang, C. C., et al. [13] suggested that teachers should help students formulate effective assessment strategies. In a teaching experiment, the students' scores improved significantly, from the pre-test to the post-test,

in three of the four tasks. Ji, Y., et al. [14] combined data mining with Massive Open Online Courses (MOOCs) and micro lectures to conduct a case study on virtual reality technology to provide ideas and techniques for implementing reliable and effective teaching intervention methods in the online teaching process. Islas, Á., et al. [15] compared the online learning strategies for individual learning outcomes of two groups of engineering students who worked as a team under the challenge-based collaboration mode. The results showed that the individual learning effect of the team participants after the intervention was significantly higher than that of the team participants without the intervention, and the average evaluation score increased. Ilic, D., et al. [16] compared the effectiveness of blended learning (BL) and teaching learning in the evidence-based ability, self-efficacy, attitude, and behavior of medical students and indicated that the students are highly inclined toward the BL method for teaching. Butz, N. T., et al. [17] pointed out that students who participate in online discussion board intervention can improve their sense of self-efficacy in establishing relationships with other online participants and explained how to use threaded discussions to support the development of relevance. Cobos, R., et al. [18] proposed a system called the edX MOOCs learning intervention system (edX-LIS) to provide MOOCs learners with information on their learning progress regularly. The author's research results showed that the intervention strategies supported by edX-LIS have a positive impact on MOOCs learners' learning motivation, persistence, and participation. Davis, D. R., et al. [19] investigated the influence of a customized short message service (SMS) reminder system to help students lessen their procrastination and improve their performance in weekly content-related tests in mixed online courses with a high enrollment rate. The results revealed that the system has a positive impact on the level of procrastination and can effectively understand the students' response to intervention measures. Smith, V. C., et al. [20] argued that effective learning intervention measures might significantly improve the learning outcomes of community learners. In the existing literature, it is evident that there is a strong emphasis on intervention measures, designed to address various learning challenges. These learning intervention measures can significantly influence various aspects of learning performance, learning satisfaction, course participation, learning interests, and so on, and has a direct impact on learning performance. Experts and scholars generally believe that learning intervention measures can improve students' learning performance and behaviors, such as learning motivation, learning interests, learning attitude, learning participation, learning duration, self-efficacy, and academic performance. This also lays the research foundation for the prediction effect of learning performance after the implementation of the intervention measures in this research.

3 METHODOLOGY

3.1 Research objectives

Based on the previous literature review and research theory, and according to the literature, this paper intends to propose three intervention methods: learning prompt intervention, process monitoring intervention, and achievement incentive intervention. This research aims to analyze the changes in and effects on students' learning performance after the application of the different intervention measures, namely, learning prompt intervention, process-monitoring intervention, and achievement incentive intervention, to verify the effectiveness of the intervention methods.

3.2 Research methods

In this research, intervention methods suitable for the online learning environment according to its characteristics were proposed. The online learning environment overcomes space-time restrictions as learning and teaching tasks primarily occur on a dedicated platform. Despite the limitation in the form of space-time separation between teachers and students, interactions such as teacher-student, student-student, and human-machine interactions are achievable. The online learning activities of the course mainly require the learners to study the course resources independently, then complete the course learning within the specified time and date, and conduct mutual evaluation among themselves to promote interaction and exchanges and increase their enthusiasm.

In this research, analysis of the learners' behavioral and cognitive data can serve as an important basis for the learning intervention. The analysis tool on the Blackboard learning platform was utilized to analyze the behavioral data. The effectiveness of the learning prompt intervention was measured by the posting quality, which was judged by the platform according to the number of words and content conformity of the students' replies. The comprehensive posting quality was indicated, ranging from 1 to 10, with two decimals reserved. The process monitoring intervention was indicated by the duration of effective online learning, with a statistical unit of an hour, directly calculated by the learning platform. Finally, the achievement incentive intervention was expressed by the online final test results, which were directly exported from the teacher side of the platform, with a score ranging from 0 to 100.

3.3 Research objects

A total of 96 undergraduate students (Class 1 and Class 2, Grade 2) majoring in civil engineering and enrolled in the Engineering Surveying online course at the College of Transportation Engineering, Huanghe Jiaotong University, Henan Province, were selected as the research objects and randomly divided into two groups (experimental group and control group), with 48 students in each group. In the experimental group, the teachers used three intervention measures: a learning prompt intervention, a process monitoring intervention, and an achievement incentive intervention. In the control group, the teachers did not employ any learning intervention measures. The course structure and learning resources of the Engineering Survey online course were complete. The online learning duration was divided into 15 modules. That is, the learning cycle was 15 weeks, 4 hours a week. Online learning was set as the online discussion activity for each module (accounting for about 48% of all the modules), each module included complete learning resources and learning activities, and the learning time for each module was set to 1 week. In the experimental group, an intervention was employed in Modules 3, 6, 9, 12, and 15, with the learning content of Module 15 as the last intervention.

4 RESULT ANALYSIS

4.1 Pre-experiment

Before the experiment, differences in the starting levels of the two groups of students were determined to verify the rationality of the grouping. For both groups,

the same learning resources, discussion activities, and evaluation standards were adopted, and the same teacher was assigned to control for the influence of irrelevant variables on the experiment. Moreover, whether the students' starting level was consistent was verified through their online final test results from the previous semester.

Table 1. Pre-experiment performance test of experimental group and control group

Sample	N	Mean	Standard Deviation	Standard Error of Mean	T-Value	Degree of Freedom	P-Value
Pre-experiment performance of experimental group	48	70.35	5.94	0.86	–0.94	90	0.347
Pre-experiment performance of control group	48	71.62	7.16	1.0			

Based on Table 1 it is evident that the corresponding P-value of the T-test was greater than 0.5, indicating that no obvious differences existed between the students in the experimental group and the control group in their online final test results in the previous semester.

4.2 Effect analysis of learning prompt intervention

Table 2. Differences in learning prompt intervention

Sample	N	Mean	Standard Deviation	Standard Error of Mean	T-Value	P-Value
Posting quality of experimental quality	48	7.423	1.418	0.205	8.23	0.000
Posting quality of control group	48	5.556	0.754	0.109		

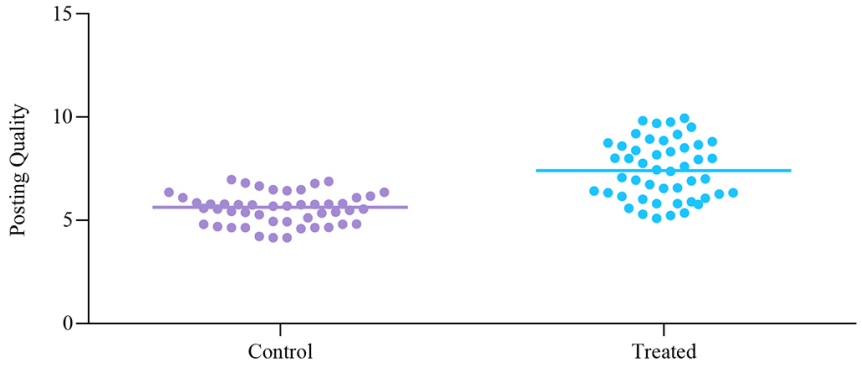

Fig. 1. Differences in posting quality

In Table 2 and Figure 1, it is clear that the posting quality of the students in the experimental group differed from that of the students in the control group. Specifically, the posting quality of the students in the experimental group was 1.867 points higher than that of the students in the control group (10-point system), which was 33.60 percent higher. The main reason behind this outcome may be that the goal of the learning prompt intervention measure is to push the curriculum learning basic information to the students and stimulate their enthusiasm to participate in the curriculum learning. In online teaching, teachers adopt the learning prompt intervention measure, which can help students understand the objectives of learning tasks, clarify the requirements of activities and their precautions, and master the specific arrangement of learning activities. Teachers can inform their students

about various aspects of the course, including the content, learning theme, learning resources, and specific starting and ending time for learning activities, By assisting students in building a solid learning scaffolding, teachers facilitate and support their completion of learning activities. Furthermore, teachers promote interaction between themselves and their students; help their students perceive the help and support in the online learning environment; increase their students' attention to the course; and improve the achievement of the course objectives. Through regular information updates, teachers remind their students about learning objectives, activities, requirements, and deadlines. They may also share information about the number of students who have completed certain learning activities. This timely communication establish a connection between teachers and students, and stimulate their students' learning interest and participation enthusiasm to improve their posting quality, which they can use to urge their students to participate in the learning activities or apply relevant intervention and provide guidance for specific problems. Teachers can communicate with their students through e-mail to provide corresponding learning suggestions, guide them to fully use their fragmented learning time to devote themselves to learning and complete the phased learning tasks, help them understand their learning situation in real-time, and improve their posting quality.

4.3 Effect analysis of process monitoring intervention

Table 3. Differences in process monitoring intervention

Sample	N	Mean	Standard Deviation	Standard Error of Mean	T-Value	P-Value
Learning duration of experimental group	48	54.852	2.802	0.404	23.19	0.000
Learning duration of control group	48	43.929	1.858	0.268		

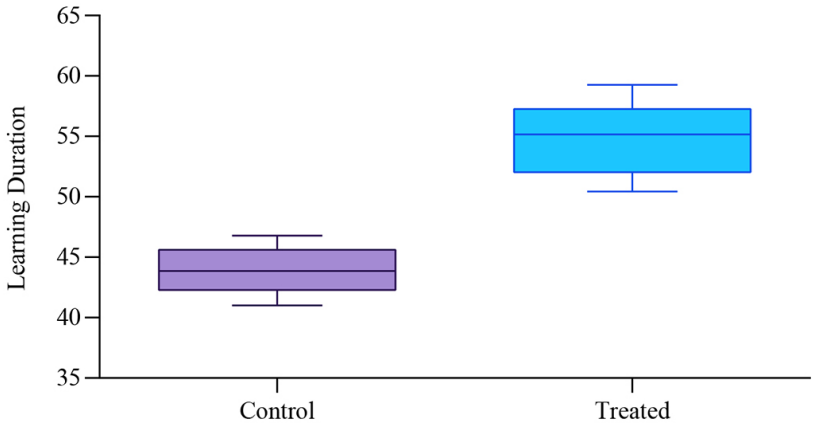

Fig. 2. Differences in learning duration

From Table 3 and Figure 2 it is obvious that differences existed between the experimental group and the control group in their learning duration. Specifically, the learning duration of the students in the experimental group was 10.923 hours longer than that of the students in the control group by 24.87%. The primary reason for the positive outcome is attributed to the effectiveness of monitoring intervention measures, where teachers or their assistants take on the role of guides and

instructors in the online learning process. They actively monitor and manage students' learning progress in real-time, providing timely support and assistance to students. This guidance helps students gain a better understanding of their learning situation and facilitate the quality of their online learning experience. Teachers are able to browse students' participation in discussion activities in real-time, enabling them to offer comments on guidance on students' posts. This promotes deeper communication among the learners, encourages the sharing of external knowledge, and prompts students to actively participate in discussion topics. As a result, a clash of views and ideas occurs, promoting critical thinking and analysis of knowledge within the context of the discussion topics. These interventions improve the quality of discussions and interaction, leading to the improvement of learners' cognitive abilities and overall learning outcomes. In learning behavior management centers, teachers can monitor students with a short learning duration, and the system will focus on the learning situation of the monitored students, and feed the students' learning situation back to the teachers. When students' learning duration is notablyshorter than the average duration, the system will trigger an early warning alarm. Subsequently the teacher will send the early warning alarm to the students to remind them that they must log in to the platform as soon as possible to participate in the course study; otherwise, an academic crisis may occur, which may affect the course learning duration and facilitate the real-time supervision of the students' learning behavior. Before proceeding to the next module, students can customize their self-management schedule and clarify their learning plans for the course to increase their online learning duration and monitor their learning progress frequently and closely, thereby improving their assignment completion time and learning performance.

4.4 Effect analysis of achievement incentive intervention

Table 4. Differences in achievement incentive intervention

Sample	N	Mean	Standard Deviation	Standard Error of Mean	T-Value	P-Value
Online final test results of experimental group	48	80.78	6.26	0.90	6.08	0.000
Online final test results of control group	48	70.78	8.72	1.26		

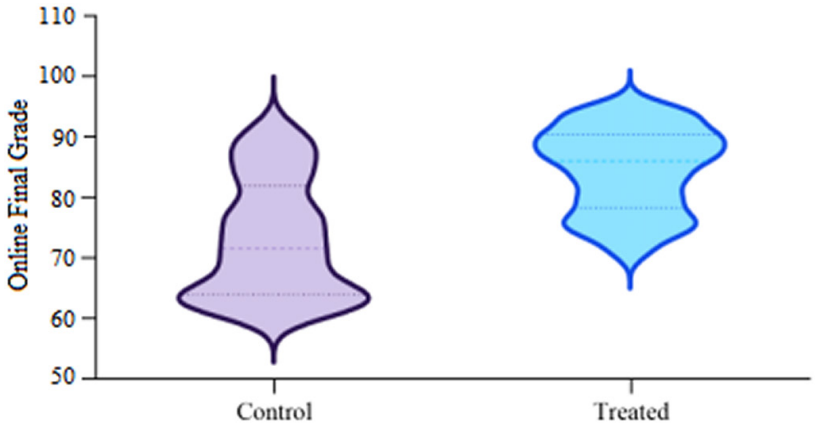

Fig. 3. Differences in online final test results

Table 4 and Figure 3 show obvious differences between the experimental group and control group in the students' online final test results. The online final test results of the students in the experimental group were 10 points higher (14.13%) than those of the students in the control group. The main reason behind this outcome may be that teachers give students appropriate encouragement and affirmation to help them gain confidence in their courses. Although online learning has many advantages, with the gradual extension of its duration students may not pay adequate attention toit. In addition, when numerous offline assignments are given, students may not submit them and lack motivation and interest in online learning, which may considerably affect their online final test results. Therefore, teachers must stimulate learners' internal drive and design curriculum resources and curriculum learning activities according to learners' characteristics and the curriculum requirements, combined with the characteristics of multidisciplinary integration, to improve the learners' satisfaction, acquisition, accomplishment, and continuous autonomous learning. On the premise of catering to student development characteristics and abiding by school rules and regulations, teachers should establish a reward and punishment mechanism and a diversified evaluation mechanism and actively guide students to participate in learning. For learners who excel in online discussion activities, teachers can directly interact with them on the discussion board. By replying to their posts, teachers can praise and acknowledge their efforts, encouraging and affirming their positive learning behavior. This recognition helps boost their confidence, enhance the harmonious development of their teacher–student relationship, promote their active participation in discussion activities, help them enhance their emotional experience in the online learning environment, correct their learning attitude, and improve their self-efficacy and online final test results.

5 DISCUSSIONS

Learning intervention measures in the online learning environment are timely, flexible, and diverse, which require teachers to prescribe the correct medicine for students' different problems and help learners conduct learning evaluations and reflections. As the most direct learning support service for learners for learning activities, learning intervention can determine learners' learning experience and final academic performance. With the development of online learning in full swing, students' learning quality has become an obstacle to the development of online learning. Tracking and recording learners' learning behavior trajectories have become possible with the improved functions of learning platforms. Conducting in-depth learning analysis on the collected data is necessary to intervene in students' learning processes to enable them to avoid learning risks and achieve academic success. Learning interventions can digitize learning behavior data with the help of learning analysis ideas and techniques. In addition, the intervention basis of learning intervention is objective, its intervention process is accurate, its intervention objects are personalized, its intervention measures are systematic, and its intervention results are highly effective. Learning interventions supported by learning analysis technology can help realize personalized and adaptive learning. Effective learning interventions can help learners complete their learning activities smoothly and contribute to the development of online learning. In this research, different learning intervention methods were employed to the research objects, and the pre-experiment data and the data before and after the intervention, were compared. It was observed that the learning prompt intervention measure could help improve the posting quality,

effective online learning duration, and online final test results. Learning intervention can create the necessary institutional conditions for the use of technology in teaching, which can help the implementation of teaching intervention and technical intervention. Teaching intervention pays attention to the role of teachers, can improve teachers' performance through online learning platforms and training evaluations, and can ensure the orderly advancement of teaching tasks. Meanwhile, technical intervention involves personalization and the usability of platforms and tools to improve teachers and students' user experiences, which is the basis for creating modules and tools on platforms. At the same time, attention must be paid to the fact that in the process of online learning, teachers or students follow targeted, planned, and purposeful invasive suggestions or guiding activities for problems encountered in the learning process. The beginning, content, frequency, and mode of learning intervention depend on students' learning status and problems.

6 CONCLUSIONS

With the continuous penetration of technology into education, online education has demonstrated a rapid development trend. In the Internet age, online learning coexists with other learning methods, and technological development promoted the popularization of online learning and made it the new means for students to acquire knowledge. The development of online learning will inevitably lead to the phenomenon of the "space-time separation of teaching behavior and learning behavior." Therefore, timely learning intervention can not only solve potential learning problems but also improve students' learning performance. In this research, the participants consisted of 96 undergraduates from classes 1 and 2 of Grade 2, majoring in civil engineering, enrolled in the Engineering Surveying online course at the College of Transportation Engineering, Huanghe Jiaotong University, Henan Province. These students were selected as the research objects, and a quasi-experimental study was conducted for 15 weeks to verify the effectiveness of different types of intervention measures on the learners' learning performance (experimental group [N = 48] and control group [N = 48]). The results showed obvious differences in the posting quality in the learning prompt intervention ($T = 8.23$, $P < 0.01$), online learning duration in the process monitoring intervention ($T = 23.19$, $P < 0.01$), and online final test results in the achievement incentive intervention ($T = 6.08$, $P < 0.01$). Continuous, in-depth research need to be conducted on online learning platforms that record large amounts of learners' data to deduce their learning behavior patterns, other online learning data sources for data acquisition should be explored, flexible and intelligent intervention strategies should be examined, and changes in learners' emotional engagement in a learning intervention should be investigated.

7 REFERENCES

[1] L. Pei and H. Wu, "Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis," *Medical Education Online*, vol. 24, no. 1, p. 1666538, 2019. https://doi.org/10.1080/10872981.2019.1666538

[2] L. Bardach, R.M. Klassen, T.L. Durksen, J.V. Rushby, JK.C. Bostwick, and L. Sheridan, "The power of feedback and reflection: Testing an online scenario-based learning intervention for student teachers," *Computers & Education*, vol. 169, p. 104194, 2021. https://doi.org/10.1016/j.compedu.2021.104194

[3] M. Liu, E. McKelroy, S.B. Corliss, and J. Carrigan, "Investigating the effect of an adaptive learning intervention on students' learning," *Educational Technology Research and Development*, vol. 65, pp. 1605–1625, 2017. https://doi.org/10.1007/s11423-017-9542-1

[4] J. Fernandez-Rio, N. Sanz, J. Fernandez-Cando, and L. Santos, "Impact of a sustained cooperative learning intervention on student motivation," *Physical Education and Sport Pedagogy*, vol. 22, no. 1, pp. 89–105, 2017. https://doi.org/10.1080/17408989.2015.1123238

[5] S.G. Forneris and C. Peden-McAlpine, "Evaluation of a reflective learning intervention to improve critical thinking in novice nurses," *Journal of Advanced Nursing*, vol. 57, no. 4, pp. 410–421, 2007. https://doi.org/10.1111/j.1365-2648.2007.04120.x

[6] D. Kiger, D. Herro, and D. Prunty, "Examining the influence of a mobile learning intervention on third grade math achievement," *Journal of Research on Technology in Education*, vol. 45, no. 1, pp. 61–82, 2012. https://doi.org/10.1080/15391523.2012.10782597

[7] J.L. Rosenblatt and M.J. Elias, "Dosage effects of a preventive social-emotional learning intervention on achievement loss associated with middle school transition," *The Journal of Primary Prevention*, vol. 29, pp. 535–555, 2008. https://doi.org/10.1007/s10935-008-0153-9

[8] P. Morris, M. Millenky, C.C. Raver, and S.M. Jones, "Does a preschool social and emotional learning intervention pay off for classroom instruction and children's behavior and academic skills? Evidence from the foundations of learning project," *Early Education & Development*, vol. 24, no. 7, pp. 1020–1042, 2013. https://doi.org/10.1080/10409289.2013.825187

[9] K.M. Cramer and S. Castro-Olivo, "Effects of a culturally adapted social-emotional learning intervention program on students' mental health," *Contemporary School Psychology*, vol. 20, pp. 118–129, 2016. https://doi.org/10.1007/s40688-015-0057-7

[10] Z. Chen, J. Jiao, and K. Hu, "Formative assessment as an online instruction intervention: Student engagement, outcomes, and perceptions," *International Journal of Distance Education Technologies (IJDET)*, vol. 19, no. 1, pp. 50–65, 2021. https://doi.org/10.4018/IJDET.20210101.oa1

[11] F.A. Rowe and J.A. Rafferty, "Instructional design interventions for supporting self-regulated learning: Enhancing academic outcomes in postsecondary e-learning environments," *Journal of Online Learning and Teaching*, vol. 9, no. 4, pp. 590–601, 2013.

[12] K. Palaniappan and N. Md Noor, "Gamification strategy to support self-directed learning in an online learning environment," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 17, no. 03, pp. 104–116, 2022. https://doi.org/10.3991/ijet.v17i03.27489

[13] C.C. Yang and H. Ogata, "Personalized learning analytics intervention approach for enhancing student learning achievement and behavioral engagement in blended learning," *Education and Information Technologies*, vol. 28, no. 3, pp. 2509–2528, 2023. https://doi.org/10.1007/s10639-022-11291-2

[14] Y. Ji and Y. Han, "Monitoring indicators of the flipped classroom learning process based on data mining—taking the course of 'virtual reality technology' as an example," as an Example," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 14, no. 03, pp. 166–176, 2019. https://doi.org/10.3991/ijet.v14i03.10105

[15] A. Islas, J.J. Franklin Uraga, P. Ortega Pérez, and A.E. Juárez-Hernández, "Theory of multiple intelligences applied to teamwork with intervention under challenge-based collaborative learning strategy for improvement of online learning," *Int. J. Educ. Res.*, vol. 9, pp. 79–92, 2021.

[16] D. Ilic, R.B. Nordin, P. Glasziou, J.K. Tilson, and E. Villanueva, "A randomized controlled trial of a blended learning education intervention for teaching evidence-based medicine," *BMC Medical Education*, vol. 15, no. 1, pp. 1–10, 2015. https://doi.org/10.1186/s12909-015-0321-6

[17] N.T. Butz and R.H. Stupnisky, "Improving student relatedness through an online discussion intervention: The application of self-determination theory in synchronous hybrid programs," *Computers & Education*, vol. 114, pp. 117–138, 2017. https://doi.org/10.1016/j.compedu.2017.06.006

[18] R. Cobos and J.C. Ruiz-Garcia, "Improving learner engagement in MOOCs using a learning intervention system: A research study in engineering education," *Computer Applications in Engineering Education*, vol. 29, no. 4, pp. 733–749, 2021. https://doi.org/10.1002/cae.22316

[19] D.R. Davis and J.T. Abbitt, "An investigation of the impact of an intervention to reduce academic procrastination using Short Message Service (SMS) technology," *Journal of Interactive Online Learning*, vol. 12, no. 3, pp. 78–102, 2013. https://doi.org/10.1016/j.jcis.2013.04.007

[20] V.C. Smith, A. Lange, and D.R. Huston, "Predictive modeling to forecast student outcomes and drive effective interventions in online community college courses," *Journal of Asynchronous Learning Networks*, vol. 16, no. 3, pp. 51–61, 2012. https://doi.org/10.24059/olj.v16i3.275

8 AUTHORS

Limin Ren, holds a Master's degree, and is a Lecturer at the College of Traffic Engineering, Huanghe Jiaotong University. Her research interests include Precision Engineering Survey and Teaching Research (E-mail: 2016082805@zjtu.edu.cn).

Kelu Fu, holds a Bachelor's degree, and is a Lecturer at the College of Traffic Engineering, Huanghe Jiaotong University. His research interests include Precision Engineering Survey and Teaching Research (E-mail: 2004070239@zjtu.edu.cn).

Ruifeng Cao, holds a Master's degree, and is a Lecturer at the College of Traffic Engineering, Huanghe Jiaotong University. His research interests include Structural Optimization Design and Teaching Research (E-mail: 2014080245@zjtu.edu.cn).