

Undergraduates' Learning Performance Under Online-Offline Blended Teaching: A System Dynamics Perspective

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ABSTRACT

The COVID-19 epidemic has greatly facilitated online teaching and learning in universities, making the factors influencing college students' learning performance and their causal feedback increasingly complex. In this regard, system thinking is used to analyse factors such as students' self-efficacy, learning significance, subjective effort, the influence of teachers and online teaching, teaching resources acquisition, and online teaching platform, to construct a causal loop diagram of college students' learning performance, and further construct a stock-flow model. The study also explores the dynamic evolution of college students' learning performance under online-to-offline teaching and the strategies to improve learning performance by the system dynamics simulations with different scenarios.

Keywords: Undergraduate, Online and offline blended teaching, Grade point, System dynamics, Simulation

1. INTRODUCTION

The COVID-19 epidemic has promoted the large-scale practice of online teaching in higher education. As of June 2020, a total of 1,454 colleges and universities in China had opened online courses, with more than 950,000 teachers offering 942,000 courses (the number of courses offered amounted to 7,133,000), and 1.18 billion college students participating in online learning. With the epidemic slowing down, the online-to-offline teaching mode of universities will become the new normal. In this context, the teaching model and style, online teaching platform and other factors will have unnoticeable impact on college students. It is of great significance to study the interaction and feedback mechanism among these factors, clarify the transmission path of their effect to explore the strategies to improve learning performance under the new normal of blended teaching.

Research on college students' learning behavior and performance in offline teaching models is copious, for example, Barksdale-Ladd and Thomas [1], Roderick and Engel [2], Amrein and Berliner [3] studied the effect of assessment mechanisms on learning attitudes, motivation and performance. Valenzuela [4], Townsend [5] analyzed the impact of growth background and access to learning resources on learning performance.

Osborne et al [6], Martín-Díaz [7], Strijbos et al. [8] investigated the impact of teacher role, teaching quality, educational background and teaching experience on students' learning. Demoss [9] argued that school climate and classroom atmosphere have a greater impact on student learning. Anh-Nguyet et al. [10] studied the effects of different teaching modes, teachers' professionalism and students' achievement on the course satisfaction; Gao [11] analysed the current situation, characteristics, structure and measurement of college students' learning motivation.

Study on online teaching has also been increasing in recent years, for example, Sahasrabudhe and Kanungo [12] investigated the relationship between media selection and course effectiveness in e-learning courses. Holland [13], Jurkovi [14] argued that the accessibility of online resources can provide more informal learning opportunities. Williams et al. [15] explored the relationship between online course engagement and learning motivation, and proposed suggestions for optimizing online teaching platforms. Wu [16] found that student traits, teacher traits, and teaching environment can significantly affect students' satisfaction with online classes; Shen [17] found that knowledge construction, teacher-student interaction, and information processing have notable positive effect on

the effectiveness of college students' online learning behaviour.

In terms of research on online and offline blended teaching, Ige and Hlalele [18] explored the impact of computer-assisted blended teaching strategies on learning performance and proposed a student-oriented approach with strengthened teachers' guidance and instruction. Xu [19] used structural equation modelling to argue that online and offline hybrid teaching helps improve college students' learning behaviours and literacy. Sharma et al. [20] proposed a multiple linear regression model to predict students' final grades in a blended learning environment, clarifying the effectiveness of online learning. Halasa et al. [21] found that blended learning significantly improved students' performance through a controlled experiment of blended and traditional learning.

The existing studies can provide useful references, however, (i) the impact of the coronavirus pandemic on traditional teaching, and the impact of fully online and blended teaching on college students' learning performance deserve in-depth study; (ii) the systemic and quantitative research on the relevant influencing factors and their interrelationships as well as the dynamic changes of learning performance needs to be strengthened. In this regard, the study adopts a system dynamics approach [22-23], which is good at dealing with high-order nonlinear dynamic and complex problems, to systemically analyze the influencing factors and their causal relationships of college students' learning performance under the blended teaching modes. This approach is used to clarify their intrinsic feedback mechanisms, construct a system dynamics model of learning performance, and explore the intrinsic dynamics mechanism and high-leverage strategies of learning performance via quantitative simulation.

2. CAUSAL LOOP DIAGRAM FOR STUDENTS' LEARNING PERFORMANCE

The factors influencing college students' learning performance mainly include subjective factors like effort and time, learning motivation, self-efficacy, and desire for self-fulfillment, as well as objective factors such as hardware facilities of school, influence from teachers, online teaching platforms and their promoting efforts. According to the interaction between these factors, [2] and [23], we proposed the causal feedback loop for college students' learning performance under blended teaching mode (Fig. 1).

1) Degree of effort → improvement rate → learning performance → performance gap → self-efficacy → learning motivation → degree of effort. This is a reinforcing feedback loop. Generally speaking, students who put in sufficient and sustained effort can improve their grade points to a certain extent and gradually close

the gap with their learning goals, further enhancing self-efficacy and learning motivation, which ultimately motivates students to work harder. It should be noted that there is a certain time delay in the transmission of the causal impact on student effort and duration on the improvement of learning performance.

2) Degree of effort → improvement rate → learning performance → performance gap → meaning of learning → learning motivation → degree of effort. This is balancing feedback loop. Learning effort promotes a narrowing of the performance gap, which will enhance students' perception of the significance of the meaning of learning, strengthen their motivation to learn, and stimulate them to become more diligent. In addition, conscientious and well-directed teachers help promote students' perceptions of the meaning of learning and motivation to learn and improve.

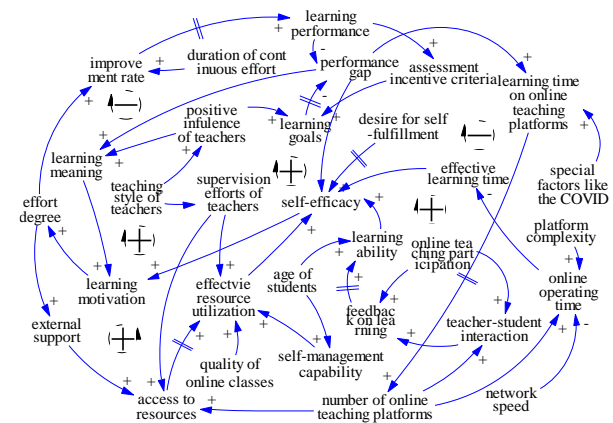


Figure 1 Causal loop diagram for college students' learning performance under blended teaching mode.

3) Degree of effort → external support → access to resources → effective resources → self-efficacy → learning motivation → degree of effort. This is a balancing feedback loop. The harder students work, the more time they will spend on self-study after class. Also, they will seek more external support from society, school, and family to obtain more effective learning resources among which are abundant both online and offline, thus motivating students to work harder with enhanced self-efficacy and learning motivation. Additionally, teachers' guidance and supervision also influence students' willingness to acquire effective learning resources to some degree.

4) Number of online teaching platforms → access to resources → effective resource utilization → self-efficacy → learning motivation → degree of effort → improvement rate → learning performance → assessment incentive criteria → learning goals → performance gap → learning time on online teaching platforms → number of online teaching platforms. This is a reinforcing feedback loop. The increase in the number of online teaching platforms expands students' access to learning resources to a certain extent, and

improves self-efficacy and learning performance via loops 3) and 1) respectively. Assessment incentive standards put forward higher requirements for students because of the improvement of their performance, which contributes to the improvement in learning goals, widening of performance gaps, and their willingness to look for more online resources, thus promoting the development of online teaching platforms.

5) Number of online teaching platforms → teacher-to-student interaction → feedback on learning → self-efficacy → learning motivation → degree of effort → improvement rate → learning performance → assessment incentive criteria → learning goals → performance gap → learning time on online teaching platforms → number of online teaching platforms. This is reinforcing feedback loop. Online teaching platform provides more opportunities for teaching interaction and collaborative learning, and students can get timely feedback on their learning, hence enhancing self-efficacy and driving the increase in the number of online teaching platforms through Loop 4).

6) Online teaching platform quantity → online operating time → effective learning time → self-efficacy → learning motivation → degree of effort → improvement rate → learning performance → assessment incentive criteria → learning goals → performance gap → learning time on online teaching

platforms → online teaching platform quantity. This is balancing feedback loop. Excessive online teaching platforms and the time wasted on software operation will affect the improvement of students' self-efficacy, and the use of online platforms eventually tends to be within a stable range through loops 4) and 5).

3. STOCK-FLOW MODEL FOR COLLEGE STUDENTS' LEARNING PERFORMANCE

With the purpose of further subdividing the types of variables (stock, flow and auxiliary, etc.) and clarify the quantitative relationship between them, the relevant factors in Fig. 1 can be further grouped into five categories of factors - society, school, family, individual, and online teaching. And the questionnaire was developed around the influence of factors such as learning motivation, learning goals, self-efficacy, school and teachers, offline and online teaching on college students' learning performance. 800 questionnaires were distributed to students at Nanjing University of Aeronautics and Astronautics and other universities with 759 valid collected. Moreover, via statistical analysis of the questionnaire results, the data set and quantitative functional relationships were constructed to obtain the stock-flow model of college students' learning performance (Fig. 2). Due to space limitation, the functions and logical relationships are not listed.

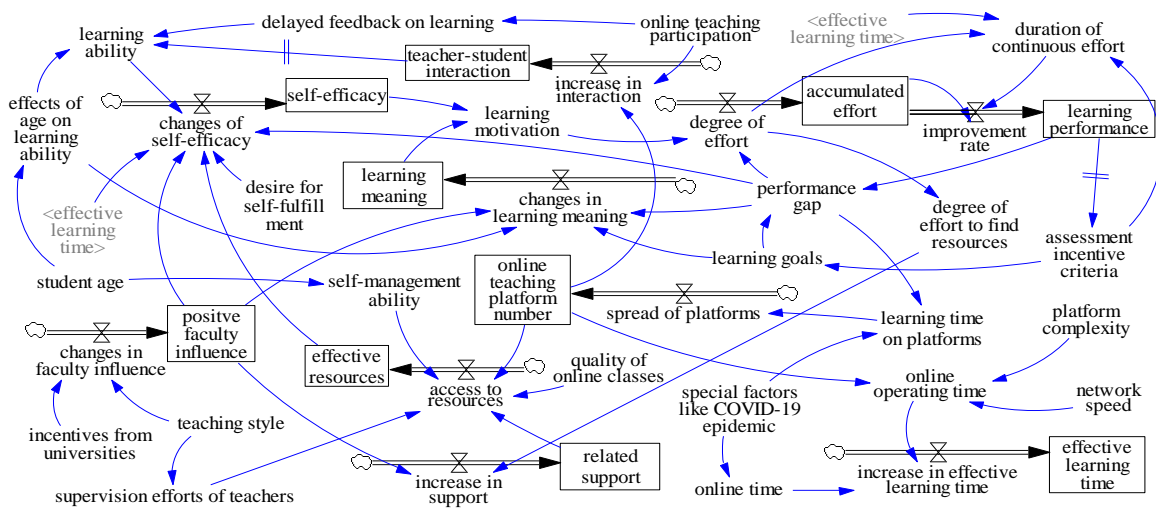


Figure 2 Stock-flow model for college students' learning performance under blended teaching mode.

4. SIMULATION RESULTS AND ANALYSIS

To simulate the evolution of college students' learning performance over a semester (approximately 20 weeks), we designed the scenarios based on factors such as student age, teacher influence, special situation factors, online teaching participation and complexity of the teaching platform.

4.1. Scenarios with students' ages

Based on four years of university undergraduate, four scenarios of 18, 19, 20 and 21 years old are set; without considering special factors such as the COVID-19 epidemic. According to Fig. 3, overall, the learning performance is best in junior year, worst in senior year, slightly better in sophomore year than freshman year, and the first two years are intermediate between the last two years. The reason why is that freshmen are new to

college, not yet completely out of high school and college entrance exams, who are full of freshness and more receptive to teachers' advice. For instance, basic courses mostly offered in freshman year, and such efforts to build a good foundation will help their subsequent studies and choices. However, the way of learning in college is obviously different from high school, and freshmen still need to ameliorate their independent learning and management skills, as well as their ability to find learning resources. With the improvement of learning style and capability and the familiarity with the environment, performance in the sophomore stage has improved in general. The third year is a special stage, on the one hand, students have greatly improved their abilities in various aspects, especially their understanding of professional courses. On the other hand, they face the critical choice of pursuing postgraduate studies or employment in their junior year. Also, students who have gaps in their learning performance and goals in the first two years often display stronger motivation to study in order to get a chance to enroll in graduate school, improve their performance points and find a better job, and thus their learning performance will be significantly enhanced. In the fourth year, most students immerse themselves in job seeking or striving for post graduate studies (except for those who are already guaranteed to enroll in graduate school), therefore, their learning performance is generally lower.

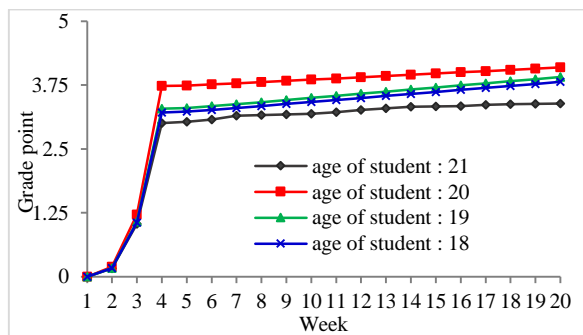


Figure 3 Learning performance under different ages of students.

4.2. Scenarios with teachers' influence

Three scenarios are set based on teachers' teaching styles - stern (teachers who are stricter with students and are instructive meanwhile), normal (more lenient with students and medially instructive), and guiding (focus on instructive teaching and moderate management). Taking freshmen students as an example, without considering special circumstances such as the coronavirus pandemic, offline teaching is mainly supplemented by online learning.

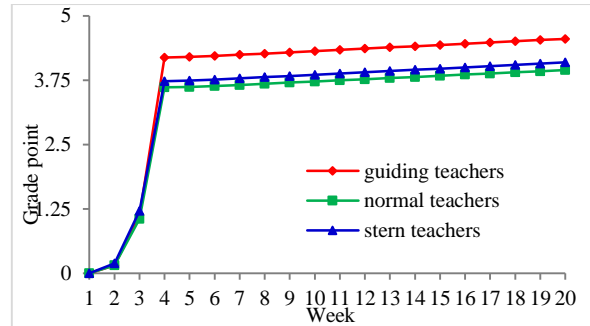


Figure 4 Learning performance under different teachers' teaching styles.

Fig. 4 shows that learning performance in the guiding teacher scenario is much higher than the other two scenarios and significantly higher than the freshman scenario in Fig. 3. Also, learning performance in the stern teacher scenario is higher than the lenient one, but the difference is not notable. This reflects that teacher's guidance has a great contribution to grade point, especially when online teaching becomes a basic teaching method, while the guiding teacher not only gives students positive learning influence, but also can give necessary guidance and management to students with poor self-control (students with poor self-control or weak motivation may waste a lot of learning time), thus enhancing their learning performance. Stern teachers are relatively strict in their control and are effective in promoting students' use of online learning resources and improving learning performance, but not as effective as the guidance type.

4.3. Scenarios with special factors like COVID-19 epidemic

Three scenarios were set up based on the impact of the COVID-19 epidemic (fully online teaching, online-offline blended teaching, and fully offline teaching).

Fig. 5 shows that there is no significant difference in learning performance in the first four weeks of the three modes, but the learning performance is highest under blended teaching after the fourth week and slightly lower under fully offline, however, all are much higher than fully online teaching. As for the reasons, the coronavirus pandemic has made it possible for the university to carry out only online instruction, and it is obvious that students have not adapted to fully online instruction, or that it is not yet a complete substitute for offline instruction. To set an example, effectiveness and efficiency of online instruction, communication, discussion, and communication is generally lower than that of the offline face-to-face mode due to the effects of network speed, screen switching, and speaking order. Moreover, teachers are unclear about what students are doing - students may have the course page open with doing something else, or may not even be in front of the computer, which makes fully online teaching and

learning much less effective. The questionnaire survey showed that about 80% of the courses took online exams in the first half of the 2020 semester, and many of the courses shortened the exams, adjusted the question types and volumes, and made the exams significantly less difficult overall, for it was the first time that fully online instruction was taught. Teachers also took into consideration student acceptance, which reflects the concerns of schools and teachers (at least for the first time) about the effectiveness of learning under fully online instruction. The online-offline blended teaching maintains the basic offline teaching, while students utilize some of the spare time they might have wasted in the past for online learning at the request and guidance of the school and teachers, obtaining more learning resources and opportunities to ask teachers questions online, thus promoting better learning performance.

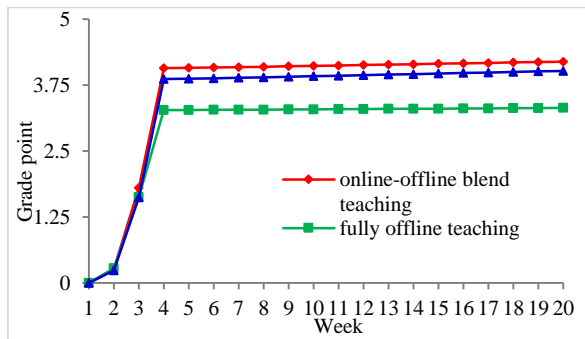


Figure 5 Learning performance under teaching mode scenarios.

4.4. Scenarios with online teaching engagement

Based on the degree of students actively participating in online teaching and learning seriously, four scenarios were set, none, low, medium and high. For instance, no engagement means students did not participate in the online course at all (not online when checking attendance), or participated (online when checking attendance) but hardly listened to the lecture or actively participated in the related teaching activities. Fig. 6 shows that the higher the level of engagement, the better the students' learning performance overall. This is because active participation and the use of online interactive features help students timely feedback their questions to the instructor. The instructor can keep abreast of students' learning and then achieve two-way communication, then facilitating students' learning. The learning performance under the scenario with low engagement is even lower than that of fully offline instruction, which suggests that online instruction may give students the opportunity to be lazy. This is because, in an online classroom with low participation, teachers cannot control whether students on the other end of the platform are listening and learning carefully. Meanwhile, they do not get as much feedback on

student learning as they do in offline teaching. Absolutely, this phenomenon is also related to teachers' online teaching methods, for example, if the online teaching is only about watching the video recording of courses or the video is too long, students may do their own things with the video on or even leave the computer, which makes students' participation significantly lower.

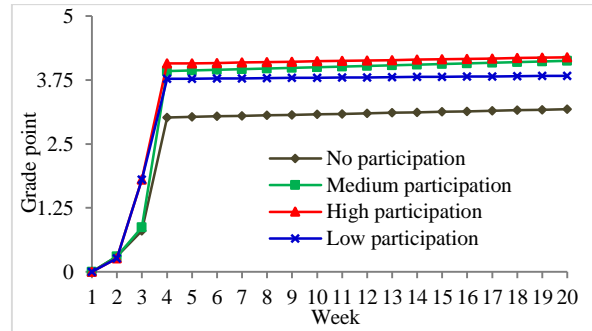


Figure 6 Learning performance under different online teaching participation.

4.5. Scenarios with online teaching platform complexity

The questionnaire manifested that the user-friendliness of the teaching platform's design and operation, its friendly interface and complexity had a certain impact on students' emotion and learning efficiency. So, scenarios of low, medium and high complexity of the online teaching platform were set based on the software operation. Fig. 7 shows that lower complexity of the platform produces higher learning performance. This is because complex platform leads to excessive time students spend on getting familiar with the platform. Moreover, there are no less than 5 kinds of online teaching platforms available now, and teachers may choose different platforms, thus students need to download several platforms for different classes, or even need to log in to multiple platforms for one class. Additionally, the network may have problems such as page crash, lag, and log-in failure occasionally, which exerts a negative effect on students' mood, participation and motivation in learning, and ultimately affects learning performance. In the case of moderate and low complexity, although students may reject the operation at first, the impact of the platform will gradually diminish or even be negligible after repeated use and familiarization.

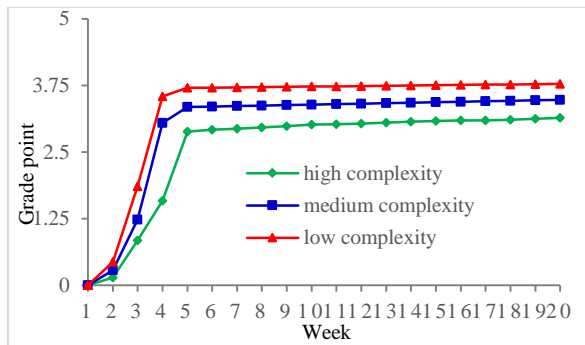


Figure 7 Learning performance under different complexity of teaching platform.

5. CONCLUSION

Through the system dynamics modeling and simulation of current college students' learning performance, the findings are as follows.

1) Teachers' supervision and guidance, especially under online and blended teaching mode, are of great significance. Online teaching allows students to have more opportunities for independent learning, and the increase in online teaching platforms provides more options. For students with strong self-control and initial learning motivation, online learning can be the icing on the cake. However, for students with low self-expectations and poor self-management skills, the effectiveness of online teaching becomes poor. At this point, teachers' proper guidance and supervision can stimulate students to participate in online teaching positively and make full use of online learning resources, thus enhancing learning performance under online teaching and blended learning.

2) In freshman year, availability of proper guidance and supervision from teachers and abundant learning resources has a significant effect on students' formation of accurate self-orientation, learning goals and learning effectiveness. Also, it helps students adapt to online and blended teaching as soon as possible and achieve relatively satisfactory learning performance.

3) While previous online teaching was generally an adjunct to offline teaching, mostly in the form of supplementary videos, free discussions, and after-class assignments, this is the first time that completely online teaching is used due to the COVID-19 epidemic, which places high demands on students' participation. The results show that it is difficult to fully understand and supervise students' state in online teaching. However, students' learning performance will significantly decrease if a high level of online teaching participation cannot be ensured. Therefore, the form and content of online teaching as well as the responsibility and guidance of teachers are crucial. To enhance students' participation in online learning, online teaching should not be based on watching videos, in addition to the basic forms of sign-in, roll call, discussion, and homework,

more interaction, guidance, and timely tracking and feedback to students should be considered in the teaching process.

4) The complexity of online teaching platforms (like the retention of complicated or not well-designed platforms, multiple choices of platform in different courses, distributed platforms for one or several courses, plus slow internet speed, lagging and log-in failure) has certain impact on student's mood and learning efficiency. In short, online teaching is often not as smooth as offline teaching. Hence the selection and unification of platforms should be considered to minimize the time students spend on platform switching, operation and waiting in compliance with the amelioration of teaching platform.

The COVID-19 epidemic in 2020 made the first time in China and even the world to adopt fully online teaching. Although it revealed many problems, the rare teaching practice and experiment had a deep impact on the university teaching and college students. With the slowdown of the coronavirus pandemic, offline teaching will gradually resume, but the proportion and status of online teaching will rise increasingly, making online-offline blended teaching a new normal, in which issues such as teachers' competence, curriculum construction, teaching design, platform construction, and students' learning styles are yet to be studied in depth to improve teaching quality and students' learning performance.

AUTHORS' CONTRIBUTIONS

Libo Zhang: conceptualization, method, reviewing, writing, supervision. Junnan Qu: method, software, data, investigation.

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