

PAPER

Effects of Different Educational Interaction Modes on Students' Independent Online Learning Ability

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Chongqing, Chinacbvcwp@126.com**ABSTRACT**

The high-speed applications of information technologies such as artificial intelligence (AI), cloud computing, and 5G promote the development of different industries and also have extensive effects on online education. Online teaching can offset normal and traditional education shortages in learning time and places and meet learners' demand for fragmented learning in the Internet era. An effective educational interaction mode can stimulate the learning interest of students, promote the occurrence of deep learning of students, and facilitate the development of their online independent learning ability. In this study, the effects of educational interaction modes (including teacher-teacher interaction, teacher-student interaction, student-student interaction, and learner-interface interaction) on the online independent learning ability of learners were analyzed based on cooperative learning theory and personalized learning theory. Differences in online independent learning ability under different contact duration with online learning were measured. Results demonstrate that the reliability coefficient and KMO value of the questionnaire are 0.889 and 0.863, indicating that the questionnaire has good reliability and validity. The teacher-teacher interaction, teacher-student interaction, student-student interaction, and learner-interface interaction of educational interaction modes can promote the improvement of online independent learning ability of learners significantly under 1%, 1%, 5%, and 1% levels, respectively. Contact duration with online learning significantly affects online independent learning ability at the 0.05 level ($F = 2.487$, $p = 0.031$). Research conclusions can provide important references to perfect the high-efficiency implementation strategy of educational interaction modes in the online classroom environment and find keyways to improve the effect and quality of synchronous classroom teaching interaction.

KEYWORDS

classroom teaching interaction, online learning, independent learning ability, questionnaire survey, analysis of variance

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1 INTRODUCTION

With the rapid development of information technology and the continuous rise of emerging industries such as the Internet of Things, human beings have comprehensively entered the information-based society. Many new technologies and methods to promote the equilibrium development of education have been developed as a response to the continuous development of "Internet + education." The synchronous classroom is a crucial way to share high-quality education resources and promote urban-rural equilibrium development in education. "Teaching interaction" refers to mutual influences and actions between teachers and students, as well as between students and students through language, body, or gesture, and teaching assisting materials in classroom teaching situations. Teaching design in an online teaching environment is more complicated than in a traditional classroom, and teaching practices often have some problems, such as insufficient communication between lecturers and teaching assistants, failure of lecturers to consider in-person and remote students simultaneously, ambiguous responsibilities and duties of teaching assistants, and the lack of collaborative evaluation and reflection of lecturers and teaching assistants. Problems with synchronous classroom teaching interaction are increasingly prominent, and the teaching effect has to be further improved. Interaction is the core of classroom teaching and has important effects on teaching effect and teaching quality. Using an effective educational interaction mode can stimulate the learning interests of students, improve their learning efficiency, and promote the occurrence of deep learning. Although effective classroom interaction stimulates students' learning interests and promotes deep learning, increasingly prominent teaching interaction problems are found in online classroom environments because of multiple subjects and the trans-time-space characteristics of synchronous classroom teaching.

Independent learning has been a research topic widely studied by educators for an extended period. In particular, online independent learning ability attracts wide attention. Some researchers have found that independent learning is important for high-efficiency online learning. Only university students who have positive learning motivations, choose appropriate learning strategies, resist external tempts to manage their learning activities strictly, and make reflections and make summaries after class can maintain academic progress. Independent learning requires learners to activate cognitive abilities, including dialectical thinking and reflection strategies, automatically according to the complicated and changing social contexts rather than simply asking learners to learn scientific and cultural knowledge or master a specific skill positively. Independent learning ability means that students develop a quality to solve practical ability based on the independent acquisition of cultural knowledge, comprehension of skills, and formation of opinions, without relying on others. It is an ability to cope with problems and keep lifelong learning. Contemporary university students need to welcome the complicated and uncertain future. In a technology-mediated learning environment, independent learning ability is conducive to strengthening interaction experiences of online learning, thus generating significant positive effects on online learning. However, many students lack independent learning ability. The positive learning process is conducive to training independent learning ability and is the key to guaranteeing learning quality under elastic teaching methods in the post-pandemic era. Therefore, if teachers implement an effective educational interaction mode and strengthen classroom teaching interaction, students can choose learning content, make learning objectives and learning plans according to their conditions through a network platform, and realize self-development and perfection of individual ability by using appropriate learning methods to adapt to the development of times.

2 THEORETICAL BASES AND HYPOTHESES DEVELOPMENT

2.1 Theoretical bases

Johnson and Johnson [1] believed collaborative learning significantly improves both the psychological atmosphere in traditional classrooms and students' academic performance. Collaborative learning refers to learning through group work to realize common learning objectives. Piaget believed that, in specific contexts, children's mutual influences can help them understand and appreciate relevant concepts better. Collaborative learning changes the boring learning atmosphere in traditional classrooms. Through collaborative learning, students can express their opinions and listen to others' opinions better, test their patience, improve their interpersonal relationships, help one another solve problems, gain a sense of satisfaction by helping others, and develop their confidence.

Carroll and Maxwell [2] proposed the personalized learning theory. They believed that independent learning does not emphasize personality but hope learners pursue personalized knowledge through independent learning, thus achieving self-values. A dynamic balance between the personality of learners and the learning environment will be reached during personalized learning, which means that the learning habits and methods should match the learning environment. According to personalized learning theory, teachers should realize the importance of respecting students' individual differences and make students pursue personal development and choose appropriate learning styles and methods according to their learning habits.

2.2 Hypotheses development

Interaction is the core of classroom teaching and influences teaching effect and quality. An effective educational interaction can stimulate the learning interests of students, improve their learning efficiency, and promote the occurrence of deep learning. Teaching interaction is believed to affect not only teaching quality but also learners' online independent learning ability.

Vaughan [3] focused on teachers' uncertainty about language use in practice and believed that teacher-teacher interaction could improve the language learning ability of teachers. Kadirova and Mastura [4] demonstrated that teacher-teacher interaction is an important teaching strategy and can improve learner engagement in courses. Smylie [5] pointed out that the professional relationship of teachers with other teachers and psychological orientation were the primary influencing factors of interaction and that teacher-teacher interaction could improve the enthusiasm of learner engagement in classrooms. Raposo and Maciel [6] investigated the collaborative establishment process of teachers and found that the trust relationship among teachers is crucial. Thus, the first hypothesis is proposed.

H1: Teacher-teacher interaction can improve the online independent learning ability of learners significantly. Cooper and McIntyre [7] believed that students benefit from teacher-centered and student-centered strategies when they are used to meet specific learning requirements of students. Pianta and Hamre [8] argued that teachers should consider the personalized learning differences of students in teaching activities and improve their learning motivation by strengthening teaching interaction with students. Yan et al. [9] pointed out that spontaneous, interactive emotions between teachers and students play an important role in creating creative classroom environments. Teachers can improve interaction efficiency with students by maintaining good

positive classroom relationships with students and setting and managing their learning emotions. Sutherland [10] emphasized that the teacher-student interaction effect has to be improved. In particular, teachers should adopt different interaction strategies to improve the interaction effect in classroom teaching. Cao [11], studying complicated teacher-student relations on online education platforms, classified them by the normal distribution division method and constructed an evaluation model of online-offline hybrid teaching coordination. Thus, the second hypothesis is proposed.

H2: Teacher-student interaction can improve the online independent learning ability of learners significantly. Borokhovski et al. [12] found student-student interaction creates a collaborative learning environment and improves student learning. Lindblom-Ylänne et al. [13] demonstrated that the academic performance of a group with good student-student interaction was better than that of a group with poor interaction and that learners in the first group participated more positively in group discussions. Hu et al. [14] pointed out that group interaction is the best learning method for young students in AI activities and can encourage group members to communicate mutually and reach a consensus. Madland and Richards [15] found that effective student-student interaction supports teaching activities and promotes deeper learning. Zhang and Chang [16] found that teacher-student and student-student interaction have a significant positive effect on continuous learning results. Thus, the third hypothesis is proposed.

H3: Student-student interaction can improve the online independent learning ability of learners significantly. Hillman et al. [17], investigating the interaction between learners and technologies, recommended learner-interface interaction as a teaching design strategy. Bringula et al. [18] demonstrated that learner-interface interaction can improve learning skills significantly, and Moore et al. [19] found that learner-interface interaction promotes teaching and learning in a specific field. Thus, the fourth hypothesis is proposed. **H4: learner-interface interaction can improve the online independent learning ability of learners significantly.**

3 METHODOLOGY

3.1 Questionnaire design

The classroom is the main battle position of educational teaching. Teacher-student, student-student, and learner-interface are major types of interactions. Generally speaking, the classroom includes traditional face-to-face and network-based online teaching. The questionnaire consisted mainly of the following three aspects. The first aspect measured educational interaction mode. In online classroom teaching, this includes the interaction between lecturers and teaching assistants, in-person and remote interaction between lecturers and students, interaction between teaching assistants and remote students, and in-person and remote interaction between students. The research results of Goh and Fraser [20] and Cho and Jonassen [21] were applied to the educational interaction mode. Interactive teaching and educational technologies were divided into four aspects: teacher-teacher, teacher-student, student-student, and learner-interface interactions. These four aspects were measured by four, four, three, and four questions, respectively. The second aspect measured online independent learning ability. The online independent learning ability used the research results of Khan and Alourani [22] and Shinkareva and Benson [23], which measured by three problems. The third aspect investigated general information about respondents, including gender, school, grades, major, and contact duration with online learning. The questionnaire used a seven-point Likert scale.

3.2 Respondents

Chongqing is a municipality in Southwest China. Chongqing possesses good higher engineering education resources. The level of computer equipment for university students has improved significantly. Moreover, an education information public service system, which is the education resource public service platform that covers basic education, vocational education, and higher education, has been developed. In this study, participants for the questionnaire survey were undergraduates from the School of Economics and Management at Chongqing Jiaotong University, Chongqing University of Technology, Chongqing College of Arts and Sciences, Chongqing City Institute of Science and Technology, Chongqing Institute of Science and Technology, and Chongqing Institute of Engineering. QR codes of the questionnaire were produced and distributed. A total of 426 questionnaires were collected. After the deletion of invalid questionnaires, 350 valid questionnaires were collected, showing an effective recovery rate of 82.16%. The general information of respondents is listed in Table 1.

Table 1. Descriptive analysis results

Name	Option	Frequency	Percentage (%)
Gender	Male	177	50.57
	Female	173	49.43
Grade	Freshman	85	24.29
	Sophomore	106	30.29
	Junior	98	28.00
	Senior	61	17.43
Schools	Chongqing Jiaotong University	56	16.00
	Chongqing University of Technology	73	20.86
	Chongqing College of Arts and Sciences	61	17.43
	Chongqing City Institute of Science and Technology	67	19.14
	Chongqing Institute of Science and Technology	41	11.71
	Chongqing Institute of Engineering	52	14.86
Majors	Accounting	53	15.14
	Tourism management	51	14.57
	Human resource management	83	23.71
	Statistics	93	26.57
	International economics and trade	70	20.00
Contact duration with online learning	<0.5 years	46	13.14
	0.5–1 year	92	26.29
	1–2 years	46	13.14
	2–3 years	79	22.57
	3–4 years	56	16.00
	>4 years	31	8.86

Table 1 shows that the percentages of males and females were relatively uniform. The grades show a low percentage of seniors due to employment and further study. The distribution of respondents in terms of schools and majors is relatively uniform. Most learners had participated in online learning for 0.5–1 year.

4 RESULTS ANALYSIS

4.1 Reliability and validity

Reliability mainly refers to the reliability, consistency, and stability of measurement results, and whether the test results reflect stable and consistent real features of respondents. This study used SPSS26.0 to measure the reliability of the questionnaire and Cronbach's α to express it.

Table 2. Reliability test results

Variable Type	Variable Name	Number of Questions	Cronbach's α	Cronbach's α
Dependent variable	Independent learning ability (Y)	3	0.924	0.889
Independent variables	Teacher-teacher interaction (X1)	4	0.941	
	Teacher-student interaction (X2)	4	0.938	
	Student-student interaction (X3)	3	0.926	
	Learner-interface interaction (X4)	4	0.917	

Table 2 shows that the reliability coefficient of the questionnaire was 0.889 (>0.8), indicating high reliability of the research data.

Table 3. KMO and Bartlett's test

KMO		0.863
Bartlett's test of sphericity	Approximate Chi-square	5377.961
	Df	153
	p-value	0.000

Table 3 shows that the KMO value was 0.863 (>0.6), indicating that information could be extracted effectively from research data.

Table 4. AVE and CR results

Variables	AVE	CR
Teacher-teacher interaction (X1)	0.799	0.941
Teacher-student interaction (X2)	0.793	0.939
Student-student interaction (X3)	0.806	0.926
Learner-interface interaction (X4)	0.740	0.919
Independent learning ability (Y)	0.802	0.924

Table 4 shows that the AVE of all five variables was higher than 0.5 and that CR was higher than 0.7, indicating the analysis data had good convergent validity.

Table 5. Pearson correlation and square roots of AVE

	X1	X2	X3	X4	Y
X1	0.894	–	–	–	–
X2	0.323	0.890	–	–	–
X3	0.249	0.263	0.898	–	–
X4	0.247	0.335	0.096	0.860	–
Y	0.263	0.261	0.240	0.269	0.896

Note: The clinodiagonal is the square root of AVE.

Table 5 shows that the square root of AVE of five variables was far higher than the maximum absolute of correlation coefficients among factors, indicating good distinguishing validity.

4.2 Linear regression

Table 6. Linear regression results

Variable	Standardization Coefficient	t-Value	p-Value	Collinearity Diagnosis	
				VIF	Tolerance
constant	–	4.902	0.000**	–	–
X1	0.181	3.395	0.001**	1.154	0.866
X2	0.158	3.023	0.003**	1.11	0.901
X3	0.113	2.037	0.042*	1.259	0.794
X4	0.143	2.654	0.008**	1.183	0.846
F (4,345) = 15.670, p = 0.000; D-W = 1.901					

Note: *p<0.05, **p<0.01.

Table 6 shows that the model passes the F-test ($F = 15.670$, $p = 0.000 < 0.05$), which implies that at least one of four independent variables influenced the independent variable. The multicollinearity test of the model reveals that the VIF value was lower than 5, indicating the absence of a collinearity problem. Moreover, the D-W value was near 2, indicating no autocorrelation in the model and no correlation among sample data. The model is relatively good.

H1 is true: Teacher-teacher interaction can improve the online independent learning ability of learners significantly. The reasons are explained as follows. Successful classroom teaching interaction activities are closely related to communication and tacit cooperation between lecturers and teaching assistants. Except for collaborative preparation, lecturers and teaching assistants have to determine their responsibilities and division of labor in the teaching process, be familiar with the teaching process, and improve the classroom teaching effect and efficiency

while guaranteeing a synchronous classroom. Thus, the collaborative teaching strategy based on collaborative theory requires lecturers and teaching assistants to share the synchronous classroom teaching tasks and emphasize their responsibilities differently. The lecturers assume the major teaching task and control the whole teaching process. They are organizers of teaching and transmitters of knowledge. Teaching assistants are managers of remote classrooms, organizers of teaching activities, and guides and helpers in student learning. Lecturers and teaching assistants influence and cooperate mutually, thus leading to the effect of $1+1>2$. Lecturers must communicate timely according to in-person and remote students' completion of activity tasks and classroom exercises to understand learning situations and the learning effects of remote students and adjust subsequent teaching links and teaching arrangements.

H2 is true: Teacher-student interaction can significantly improve the online independent learning ability of learners. Teacher-student interaction is an important component of classroom teaching activities and influences the final effect of classroom teaching. It has to ensure diversity and effectiveness of teacher-student interaction activities to improve in-person and remote students' enthusiasm and initiative in classroom teaching activities and motivate their multi-sense engagement fully. Diversified and effective teacher-student interaction activities can help lecturers accurately understand students' knowledge and skill comprehension in person and remotely so that they can adjust the teaching pace timely and promote the development and growth of in-person and remote students better. After answering students' questions, lecturers should give timely feedback and responses and guide students to reflect on problems to form high-efficiency interaction structures. Through continuous guidance and deep feedback from lecturers, in-person and remote students can interact productively, enabling them to train and develop their thinking ability and realize deep learning. While diversified forms of teacher-student interaction are needed, teacher-student interaction quality is more important. Deep teacher-student interaction is fundamental to guarantee the teaching effect of a synchronous classroom.

H3 is true: Student-student interaction can improve the online independent learning ability of learners significantly. Student-student interaction activities can stimulate learning enthusiasm and initiative of students, and train a spirit of teamwork and friendly competition among students. Such interaction has to guarantee the effectiveness and feasibility of student-student activities to stimulate enthusiasm and motivation of in-person and remote students to participate in student-student interaction. Engaging and interesting student-student interaction activities provide more training opportunities for in-person and remote students, increase their enthusiasm and initiative, and develop their potential abilities. They also offer students more opportunities for exhibition and cooperation and train a cooperative mindset and ability. As a result, classroom teaching can teach knowledge to students while fostering social skills. Student-student communication and interaction can promote emotional communication, expand their horizons, widen their knowledge, stimulate their pursuit of a good life, and train good, productive study habits. Organizing student-student communication and interaction should not be a mere formality but should require the full consideration and careful arrangement of online activities by school leaders, instructors, researchers, and teachers. Each activity should have an explicit goal, clear tasks, and detailed activities to develop the advantages of offline communication and promote emotional communication among in-person and remote students.

H4 is true: Learner-interface interaction can improve the online independent learning ability of learners significantly. Learner-interface interaction refers to the interaction between humans and machine, and it is essentially the interaction between humans and computers. It can achieve high-frequency, real-time learner-interface interaction through the intelligent guidance learning system. Students can have high concentration, and their attention can be far greater than in traditional classrooms. The traditional single teaching mode of teachers can be boring, which can make it difficult to attract the attention of children who love to play in nature, not to mention learning interests, and developing independent learning. Online classrooms will mostly use game-based teaching modes that students are interested in and can help them acquire knowledge in the gamification process. Stimulating learner-interface interactions attract students' attention and stimulates their learning interests by integrating multiple forms, such as text, pictures, video, and audio, thus improving students' independent learning ability.

4.3 Difference analysis

Table 7 shows that contact duration with online learning significantly influences online independent learning ability at the 0.05 level ($F = 2.487$, $p = 0.031$), which is mainly because online learning requires more independent learning of learners and contact duration, leading to significant differences in the independent learning ability of learners. Specifically, learners who have participated in online learning for over four years show the best online independent learning ability. This finding proves that online learning must improve learners' familiarity with tools and improve their learning skills by increasing contact duration. Online teaching is not just a technology; a simple technology can be formed only by combining new design and implementation. Therefore, learners who have participated in online learning for a longer period achieve better performances than those with less exposure to online face-to-face communication, use of PowerPoint and electronic textbooks, and comprehensive use of network resources. University administrators must pay attention to the teaching contents of teachers in online learning and give full consideration to learners' proficiency in using online learning equipment to give them enough time to master various skills fully.

Table 7. Variance test results

Contact Duration with Online Learning	Online-Independent Learning Ability
<0.5 years	4.54 ± 1.21
0.5–1 year	4.83 ± 1.57
1–2 years	4.00 ± 1.53
2–3 years	4.39 ± 1.50
3–4 years	4.54 ± 1.32
>4 years	4.84 ± 1.10
F	2.487
p	0.031*

Note: * $p < 0.05$.

5 CONCLUSION

Online learning has developed from an emergency to a “new normal situation.” Educators are increasingly concerned about independent learning ability as a research topic. Independent learning is an important condition for high-efficiency online learning. Learners with positive learning motivation, choosing appropriate learning strategies, and managing their learning activities make optimal use of independent learning. By implementing a high-efficiency educational interaction mode, teachers can improve the enthusiasm and initiative of students to participate in classroom activities effectively and promote significant establishment and deep learning of students. This study investigated the effects of educational interaction modes (including teacher-teacher, teacher-student, student-student, and learner-interface interactions) on learners' online independent learning ability and the differences in online independent learning ability under different contact durations with online learning. Some major conclusions can be drawn: (1) the reliability coefficient and KMO of the designed questionnaire were 0.889 and 0.863, indicating the questionnaire's reliability and validity. (2) Teacher-teacher, teacher-student, student-student, and learner-interface interactions can improve learners' online independent learning ability significantly: under 1%, 1%, 5%, and 1%, respectively. (3) Contact duration with online learning significantly influences online independent learning ability at the 0.05 level ($F=2.487$, $p=0.031$). It is suggested that the survey range of educational interaction modes be expanded further, that long-term data monitoring be implemented, and that influencing factors on the educational interaction mode in the hybrid teaching process continue to be discussed in the future.

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