

# Influence of a Distributed Learning Environment on Learners' Performance

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**Abstract**—Online high-quality teaching and learning behaviors can take place anytime and anywhere, which comprehensively breaks through isolation of physical space. Individual learning in a distributed learning environment is an activity that is transformed from process of individual self-cognition to social cognition of the group. It attaches great importance to interactive behaviors in learning. By strengthening cooperative learning, learning motivation can be further stimulated and learning performance can be improved. A questionnaire about the influence of distributed learning environment on learners' learning performance was designed. Influence of four components of distributed learning environment interaction on learners' learning performance was measured, and the mediating effect of collaborative learning on the interaction between learners' learning performance and distributed learning environment was analyzed. Results show systematic management support of self-knowledge, support of learners' expression and support of self-reflection can significantly improve learning performance of learners. Collaborative learning plays a full mediating effect in the interaction between distributed learning environment and learning performance of learners. Grade is significant at 0.01 level for learning performance. Conclusions are of great significance to promote occurrence of effective learning behaviors in interactive process of collaborative learning from the perspective of distributed learning environment.

**Keywords**—distributed learning environment, learners, learning performance, mediating effect, questionnaire survey, variance test

## 1 Introduction

With the comprehensive development of modern information technology, new technologies such as big data and cloud computing have brought new teaching models to current education. Distributed learning environment can make use of teaching space distributed in the network so that learners can obtain learning resources anytime and anywhere. Distributed learning environment is developed based on the theory of distributed cognition. Learning is an activity transforming from process of individual self-cognition to social cognition of the group. It has a strong focus on interaction in learning. By forming a learning community, learning is transformed into a community of shared values, collaborative learning, sharing of resources, exchange of experience and upgrading of skills. Distributed learning environment is a kind of

learning environment constructed on the basis of distributed cognitive theory, aiming to use all technical means to provide the same learning place and communication place for geographically dispersed learners.

In the distributed learning environment, it is necessary to provide rich learning resources for geographically dispersed learners and to have characteristics of convenient knowledge acquisition, harmonious man-machine dialogue and unobstructed interaction. In the distributed learning environment, the content and way of learning activities can be greatly updated and changed. Distributed learning environment can stimulate learners' enthusiasm for participation and maintain positive social relations among learners, which can further promote meaningful dialogue among learners. It plays an important role in promoting effective interaction between individual students, between students and teaching organizers, between students and learning content, between students and collaborative tools, and between students and learning situations. At the same time, collaborative learning is an effective way to solve learning difficulties and improve learners' learning behavior. Learning community can promote meaningful occurrence of collaborative learning through interaction, such as mutual discussion, sharing of ideas, process supervision and emotional support. In process of interaction, it can expand depth and breadth of knowledge grasped by individuals and knowledge constructed cooperatively by groups, improve higher-order cognitive ability of learners and gather wisdom of groups. Learners' cooperation skills can be cultivated, attraction between individuals and solidarity between groups can be deepened, and a harmonious cooperative learning atmosphere can be created.

## **2 Theoretical basis and hypothesis development**

### **2.1 Theoretical basis**

Nickerson [1] believed that Distributed Cognition, as a cognitive theory including cognitive subject and environment, advocated placing individual cognitive activities in situations and social culture. It was emphasized that cognitive phenomena were widely distributed within individuals, among individuals, media, learning environment, social culture and time, which analysis element system covering cognitive subjects and environment and all involved in cognitive things. Theory of distributed cognition explained in detail cognitive mode of human behavior, how to get out of self-world of the individual and how to disperse into social environment. Individual cognition was not an independent thing, but was a process of interaction between individuals, environment and technology tools. Therefore, creation of distributed learning environment should be able to promote effective occurrence of learners' collaborative learning interaction process and to provide support conditions for effective interaction between individuals and environment, between tools and individuals. In learning community established, people could fully speak their minds, communicate with peers, share ideas and evaluate each other, to obtain more profound cognitive experience. Moreover, diverse collaboration tools provided by distributed learning environment made learning style become a distributed activity, which not only existed in minds of individuals, but also was distributed in interactions between individuals, between individuals, various tools and learning environment. Therefore, inspired by relevant knowledge of distributed

cognitive theory, it should pay more attention to interaction between individuals and other individuals, resources, technology and environment in collaborative learning interaction process under this environment.

## 2.2 Hypothesis development

In process of collaborative learning interaction in a distributed learning environment, learning situation refers to learning conditions that can provide learners with learning partners, learning resources and learning tools to interact. About distributed learning environment interaction, this study argues that interaction factors of distributed learning environment can be summarized as four aspects, namely systematic management support of self-knowledge, support of learners' expression, support of self-reflection and support of self-evaluation.

In terms of relationship between self-knowledge and learning performance, Wilson et al. [2] mainly believed that other ways to increase self-knowledge included observing oneself through eyes of others and observing one's behavior. It was usually beneficial to improve construction of self-knowledge. Letmathe et al. [3] proved that explicit knowledge transfer was superior to other forms of knowledge transfer. Markus [4] certified that self-knowledge was an important part of personality, and that self-knowledge management was the closest connection between personality and behavior. Boyle [5] thought that self-knowledge was closely related to the ability of rational thinking. Morin et al. [6] argued that internal speech paralleled self-knowledge state and was used more often in highly self-aware people. McCrindle et al. [7] found that experimental group used more metacognitive strategies and more complex cognitive strategies in learning task, showing more complex learning concepts and higher awareness of cognitive strategies. Chen [8] showed that learners' self-regulation learning ability was an important factor affecting learning performance in e-learning environment, which could improve learning performance of individual learners. Lai et al. [9] thought that integrating self-regulation strategy into flipped learning could improve students' self-efficacy and strategies for planning and using learning time, to effectively learn and achieve better academic performance. Therefore, hypothesis H1 is proposed.

*Hypothesis H1: Systematic management support of self-knowledge can significantly promote learners' learning performance.*

As for the relationship between learners' expression and learning performance, Nurhayati [10] showed that students' free expression and organization of their ideas in a positive way had a good promotion effect on English writing learning. Vorobel et al. [11], through a qualitative case study, proved that a good expression of positive self and identity was conducive to young people establishing good values. Viel-Ruma et al. [12] showed that the writing ability of high school students with written expression impairment could be improved through implementation of science direct teaching writing program. Larrotta et al. [13] believed that learners faced great challenges in process of participating in adult education and English literacy teaching and that learners' strengthened expression could improve their language expression skills. Therefore, hypothesis H2 is proposed.

*Hypothesis H2: Support of self-expression can significantly promote learners' learning performance.*

As for the relationship between self-reflection and learning performance, Lew et al. [14] showed that self-reflection on students' learning styles and content could indeed improve academic performance, but to a limited extent. Chen et al. [15] showed that students' self-reflection on how to use available resources for learning and that more effective use of their learning resources could improve their classroom performance. Pai et al. [16] showed that self-reflection played a mediating role between anxiety and nursing ability. Teachers' encouragement of learning could have a positive impact on students' self-reflection and further improve students' clinical nursing ability. Lew et al. [17] showed that students could enhance their reflective ability by keeping diaries and that their reflective ability improved with progress of the academic year. Jou et al. [18] developed a web-based self-reflective learning system to improve students' learning of industrial technology. Results showed that web-based self-reflective learning systems could effectively improve academic performance of backward students. Kitsantas et al. [19] showed that self-regulated learners would show greater skill acquisition, more positive tendencies, and higher perceptual tool teaching planning. Carr et al. [20] showed that the stronger students' reflective ability, the higher their academic performance. Therefore, hypothesis H3 is proposed.

*Hypothesis H3: Support of self-reflection can significantly promote learners' learning performance.*

As for the relationship between self-evaluation and learning performance, the results of Olina et al. [21] showed that teacher assessment and self-assessment could enable learners to obtain significantly higher scores from independent assessors. Students with higher self-assessment scores were more confident in their ability to conduct future experiments. Diep et al. [22] showed that self-evaluation could improve learning motivation and make learning performance of adult learners more obvious. Gramzow et al. [23] believed that there was a close relationship between self-evaluation and college students' academic performance. Hewitt [24] found that there was a strong and positive relationship between self-efficacy and music performance and self-evaluation. Brosan et al. [25] found that there was a significant correlation between self-assessment and expert assessment of competence, but therapists significantly overestimated their competence compared with expert assessors. Plakht et al. [26] found that higher scores, clinical practice and learners' scientific self-evaluation were related. Stallings et al. [27] showed that students' self-assessment could be used to improve students' confidence in mathematical ability, make them more independent in mathematical learning, help develop their communication skills, and increase their mathematical vocabulary. Therefore, hypothesis H4 is proposed.

*Hypothesis H4: Support of self-evaluation can significantly promote learners' learning performance.*

The key to collaborative learning was efficient interaction between individuals and other members of the group, allowing knowledge to be shared through different learners expressing their views. Cen et al. [28] believed that learners could provide effective

learning help and support to each other through learning interaction. Zhu [29] believed that in collaborative learning model, learners could fully express themselves, put forward their own opinions and improve the learning atmosphere. Fakomogbon et al. [30] believed that collaborative learning could improve learning interest and enthusiasm and that learners' learning level could be significantly improved. Stacey [31] believed that overall collaborative learning of learners in online learning could improve students' learning activities. Blasco-arcas et al. [32] showed that active and collaborative learning was an important factor in improving students' academic performance. Wang et al. [33] showed that online discussion and collaboration could form a positive learning atmosphere. Saqr et al. [34] showed that online collaborative discussion could increase a lot of interaction. Research results of Chan et al. [35] showed that active collaborative learning played a mediating role between interaction and students' academic performance. Therefore, hypothesis H5 is proposed.

*Hypothesis H5: Collaborative learning plays a mediating effect in the interactive promotion of learners' learning performance in a distributed learning environment.*

### **3 Methodology**

#### **3.1 Questionnaire design**

Based on the existing research literature, this study designs the questionnaire on “influence of distributed learning environment interaction on learners' learning performance”, mainly including the following four aspects. The first aspect is to survey the learners, including gender, major, grade and other three questions. The second aspect is measurement of independent variables [36]. There are 5, 5, 3, and 6 measurement questions corresponding to the four aspects of systematic management support of self-knowledge, support of learners' expression, support of self-reflection, and support of self-evaluation. The third aspect is measurement of learning performance. This study adopts 8 measurement problems [37–38]. The fourth is measurement of collaborative learning. In this study, five measurement questions from Razal et al. [39] are used. All questions are finally measured using a 5-point Likert scale.

#### **3.2 Research objects**

Collaborative learning activities in distributed learning environment need a relatively good foundation of higher education. Shanghai is a very developed area of China's higher education. Shanghai can systematically promote its digital transformation and comprehensive reform of education, advance education construction experiment site area of digital transformation, use modern information technology, education mode, education content, education mode and management organization form, explore new models of education wisdom to promote online education, and actively adapt to new trend of future education development. As business administration is more popular in economically developed areas such as Shanghai, with a large number of applicants every year, various colleges and universities have increased information funding support for such majors. Therefore, this study distributes online questionnaires to

five majors of business administration in six schools, including Shanghai University of Science and Technology, Shanghai International Studies University, Shanghai University, East China University of Science and Technology, Donghua University and Shanghai Ocean University. A total of 304 questionnaires are recovered, and 241 valid questionnaires are obtained after removing invalid questionnaires, with an effective recovery rate of 79.28%.

**Table 1.** Descriptive statistical results

Name	Options	Frequency	Percentage (%)
Gender	Female	152	63.07
	Male	89	36.93
Grade	Freshman	78	32.37
	Sophomore	81	33.61
	Junior	22	9.13
	Senior	60	24.9
Major	Business administration	30	12.45
	Accountancy	63	26.14
	Human resource management	66	27.39
	Auditing	53	21.99
	Marketing	29	12.03

## 4 Results analysis

### 4.1 Reliability and validity analysis

Reliability test is a test of the consistency of results obtained by repeated measurement of the same object using the same method. Reliability reflects size of random measurement errors. High reliability means that the results of multiple measurements on the same thing can be consistent, indicating that measurement tool is reliable and stable.

**Table 2.** Reliability test result

Variable Types	Variable Name	Number of Problems	Cronbach's $\alpha$ Coefficient	Cronbach's $\alpha$ Coefficient
Independent variables	Systematic management support of self-knowledge	5	0.754	0.812
	Support of learners' expression	5	0.936	
	Support of self-reflection	3	0.720	
	Support of self-evaluation	6	0.845	
Dependent variable	Learning performance	8	0.764	
Mediating variable	Collaborative learning	5	0.920	

As can be seen from Table 2, the overall Cronbach's  $\alpha$  coefficient of the questionnaire is 0.812, greater than 0.8. Meanwhile, Cronbach's  $\alpha$  coefficient of each variable is also higher than 0.7, indicating that the reliability of the questionnaire is very good.

Validity test refers to the degree to which measuring tools or means can accurately measure the thing to be measured, that is, to what extent it reflects objective truth of the thing.

**Table 3.** The KMO and Bartlett tests

The KMO Value		0.806
Bartlett sphericity test	Approximate chi-square	4237.585
	df	496
	P value	0

As can be seen from Table 3, the overall KMO value is 0.806, and the  $P$  value of the Bartlett sphericity test is 0.000, indicating that the validity is very good.

#### 4.2 Linear regressions

**Table 4.** Linear regression results

Variable	Coefficient of Standardization	T Value	P Value	Adjusted R <sup>2</sup>	F Value
Constant	–	5.154	0.000**	0.872	F(4,236) = 5.679, $p = 0.000$
Systematic management support of self-knowledge	0.176	2.783	0.006**		
Support of the learner's expression	0.138	2.203	0.029*		
Support of self-reflection	0.137	2.076	0.039*		
Support of self-evaluation	0.030	0.455	0.649		

Notes: The D-W value is 1.849. \* means  $p < 0.05$ , and \*\* means  $p < 0.01$ .

As can be seen from the results in Table 4, the F test of the model finds that the model passes the F test ( $F = 5.679$ ,  $P = 0.000 < 0.05$ ), indicating that at least one of independent variables has an impact on dependent variable. In addition, test of multicollinearity of the model finds that all VIF values in the model were less than 5. It means that there is no collinearity problem, and the D-W value is 1.849, around 2, which indicates that there is no autocorrelation in the model. There is no correlation between the sample data, indicating that the regression model is good.

- (1) Hypothesis H1 is valid. That is, systematic management support of self-knowledge can significantly promote learning performance of learners. In distributed teaching environment, individual learners interact with learning situations and learning resources. Learners can acquire meaningful learning content through public platforms and open platforms, and on the basis of self-knowledge generation. The stronger a learner's systematic management ability of self-knowledge is, the more



likely he or she is to make more detailed inner knowledge processing and to complete construction of self-knowledge through active assimilation by combining meaningful knowledge with existing cognitive schema. This stage is process of students' transformation from individual explicit knowledge to tacit knowledge, and it is students' re-cognition and innovation of their explicit knowledge on the basis of self-internalization.

- (2) Hypothesis H2 is valid. Support of learners' expression can significantly promote learning performance of learners. The main reason is that only by sharing individual knowledge with others can it become useful knowledge for the group and promote sharing and creation of knowledge among members of the community. Therefore, in interactive process of collaborative learning in this environment, learners share individual explicit knowledge through discussion to complete collaborative learning tasks or when their peers have needs. Support of learners' expression is mainly that distributed learning environment always expresses its views on problems in collaborative tasks, and carries out interactive behaviors in the form of discussion, communication, sharing, consultation and argument. To a certain extent, it is beneficial to formation of learners' deep cognition, improvement of problem-solving ability and cultivation of critical thinking. At the same time, support of learners' expression is also reflected in interaction with teachers. Feedback given by teachers plays a positive role in enhancing learners' reflection.
- (3) Hypothesis H3 is valid. Support of self-reflection can significantly promote learning performance of learners, mainly because the teacher is still dominant force in teaching in distributed teaching environment. Teaching needs to comprehensively guide discussion and communication among collaborative groups according to teaching content, and to guide them to a certain extent to avoid ineffective interaction caused by deviation from interactive theme. Through self-reflection, learners can self-reflect on the effect of collaboration and interaction, and promote learners to reflect on teaching content and learning performance. Occurrence of self-reflection has a positive incentive effect, guiding learners to adopt more continuous learning behavior, and learning performance level is easy to at a higher level.
- (4) Hypothesis H4 is not valid. Support of self-evaluation does not significantly promote learning performance of learners. Students' self-evaluation is an evaluation strategy to promote effective occurrence of collaborative interaction process. However, the results of this study do not support this conclusion. The main reason is that in distributed teaching environment, teachers can evaluate learners according to the frequency of posting in the learning community, number of posts and completion of collaborative group tasks. At the same time, mutual evaluation between students and the collaborative group can refer to contribution degree of individual students to completion of the group task and satisfaction degree of collaborative learning achievement of the group. But the learner's self-evaluation depends on task completion and number of discussion with study partner. With time extension, learners are easy, or even no longer to overlook self-evaluation, which makes that support of self-evaluation on learners' learning performance is not easy for longer ranges.



### 4.3 Mediating effect analysis

**Table 5.** Mediating effect

	Learning Performance	Collaborative Learning	Learning Performance
Constant	3.533** (14.029)	2.959** (13.226)	2.983** (9.107)
Distributed learning environment interaction	0.090 (1.476)	0.277** (5.110)	0.039 (0.608)
Collaborative learning	–	–	0.186* (2.582)
Sample size	241	241	241
F value	F(1,239)=2.179, p=0.141	F(1,239)=26.112, p=0.000	F(2,238)=4.450, p=0.013

Notes: \* means  $p < 0.05$ , and \*\* means  $p < 0.01$ . Inside the parentheses is the  $t$ -value.

It can be seen from Table 5 that collaborative learning plays a full mediating effect in interactive promotion of learners' learning performance in distributed learning environment. The main reason is that in distributed learning environment, students voluntarily form a learning community under guidance of teachers, and carry out synchronous collaborative learning interactions within or between groups, to achieve objectives of collaborative learning and to share learning outcomes. Learners can obtain required resource interactions from learning resource base in this environment and internalize them into their tacit knowledge. Learners communicate and interact with their learning partners in distributed discussion groups. In this process, learners can externalize individual tacit knowledge to cooperative learning partners in form of text, audio, video, or other works, to realize successful transformation of tacit knowledge to explicit knowledge (collaborative tool interaction). Information feedback is carried out between partners, so that learners can further restructure their cognitive structure and complete construction of individual knowledge in communication and interaction. At the same time, it also contributes to output of group collaborative knowledge creation, and finally completes the task of group collaborative learning.

### 4.4 Difference analysis

**Table 6.** Analysis of variance

	Major (Mean ± standard deviation)					F	p
	1.0 (n=30)	2.0 (n=63)	3.0 (n=66)	4.0 (n=53)	5.0 (n=29)		
Learning performance	4.13±1.14	4.14±1.03	4.02±1.20	4.17±1.03	4.17±0.85	0.211	0.932
	Grade (mean ± standard deviation)				F	p	
	1.0 (n=78)	2.0 (n=81)	3.0 (n=22)	4.0 (n=60)			
	4.09±1.11	4.15±1.13	4.82±0.50	3.93±1.02	4.241	0.006**	

Note: \* means  $p < 0.05$ , and \*\* means  $p < 0.01$ .

As can be seen from Table 6, grades show a significance of 0.01 level for learning performance ( $F=4.241$ ,  $p=0.006$ ), and specific comparison between differences shows that the third grade is higher than the other grades. The main reason may be that freshmen have received online learning in high school, but there is novelty in distributed learning environment in university, which makes them have a higher level of learning performance. With time, learning performance of the third year in distributed learning environment reaches the highest value. However, senior students may face more employment pressure, which makes their academic performance level gradually decline. The conclusion also inspires that college teachers should consider the student's grade factors in the use of distributed teaching environment for teaching, and that different grades of college students is not the same as demand for distributed teaching link, which needs more for different grade students in teaching, teaching mode, teaching contents of optimization design.

#### **4.5 Discussion**

In process of learning interaction in distributed learning environment, systematic management support of self-knowledge, support of learners' expression and support of self-reflection can promote learning performance of learners. Constructivist learning theory holds that learning is essentially a systematic process in which learners actively construct knowledge, and a process in which learners form, enrich and adjust their experience structure, knowledge level and knowledge accumulation through interaction of old and new experiences. In distributed learning environment, teachers and learners can reflect learners' learning performance through good learning interaction. Distributed learning environment is a learning environment based on the theory of distributed cognition, which holds that learning is an activity transforming from process of individual self-cognition to social cognition of the group, which has a strong focus on interaction in learning. By forming a learning community, learning is transformed into a community of shared values, collaborative learning, sharing of resources, exchange of experience and upgrading of skills. Educational viewpoint of improving learners' learning performance by adding collaborative learning in distributed learning can break through many misunderstandings in traditional education closed systems and improve quality of online learning.

### **5 Conclusion**

Rapid development of information technology has a profound impact on education and teaching, and how application of technology in teaching activities affects learning performance has become focus of attention. Distributed learning environment is a kind of learning environment constructed on the basis of distributed cognitive theory. It can use all technical means to provide the same learning place and communication place for geographically dispersed learners, to improve learning effect. This study calculates influence of four components of distributed learning environment interaction on learners' learning performance. It analyzes mediating effect of collaborative learning on interaction between learners' learning performance and distributed learning

environment. Results show that the reliability and validity of the questionnaire are good. Systematic management support of self-knowledge, support of learners' expression and support of self-reflection can significantly improve learning performance of learners. Collaborative learning plays a full mediating effect in interaction between distributed learning environment and learning performance of learners. Grade has a 0.01 level significance for learning performance. It is suggested that further research should be carried out on the relationship between individual learning styles and learning performance, the dynamic relationship between different learning styles and learning performance in a distributed environment, and how the application of teaching strategies of distributed learning model affects learners' learning motivation.

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