The Effect of Student and Peer Assessment Engagement on Learning Performance in Online Open Courses

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Abstract—A large number of online education platforms in China has greatly facilitated the development of online education by allowing people to access quality educational resources at all times. Enhancing student engagement can effectively realize their learning efficiency and improve the overall learning process performance and final learning performance. Peer assessment generally requires learners to engage in a range of cognitive activities, such as critical thinking, monitoring, and reflecting, and has a positive and significant contribution to learning performance. In this study, an argumentative model of student engagement affecting learning performance was constructed, and the role of peer assessment engagement as a moderating variable in student engagement involving learning performance was analyzed. Results show that behavioral engagement and cognitive engagement can significantly contribute to learning performance. Peer assessment plays a moderating role in learning engagement, significantly contributing to learning performance. The average value of students' final learning performance is significantly higher than that of midterm performance. Conclusions are valuable for improving the accuracy of peer assessment results, promoting learners' reflection on learning, and constructing online peer assessment models based on learning behavior data.

Keywords—online open courses, student engagement, peer assessment engagement, learning performance

1 Introduction

Over the last decade, China has been vigorously developing education informatization technology, which has led to an overall improvement in education informatization in China, and the number of online open courses has continued to increase. Online education platforms, especially those represented by Icourse163, MOOC, and XuetangX, have made quality educational resources available anytime, greatly promoting the development of online education. The rise of online education also poses serious teaching challenges for teachers on the platform. China's education administration has explicitly requested schools at all levels to pay full attention to the supporting role of Big Data and AI technologies in the digital learning process and explore new education forms

and teaching methods and models that provide for inter-temporal and personalized learning for learners. Using various information-based teaching aids (including hardware and software) in the online learning process has become the mainstream for future online teaching reforms in China. The advantages and potential of online information-based teaching are gradually demonstrated and confirmed. Schools and colleges are actively exploring the role of information technology in promoting education and teaching, which undoubtedly has far-reaching significance and impact on teaching research and practice in various fields. Learning assessment includes teacher and peer assessment. Efficient and high-quality assessment can make the online open learning process. Learners become more interested through a variety of information feedback to achieve interactive communication between teachers and students and interactive communication between classmates, which is conducive to increasing the internal learning effectiveness of learners. However, online open courses need more engagement in the specific teaching practice. Meanwhile, because of the characteristics of online open courses with a large base of learners and without or with some fees, learners' identity in online learning is complicated. Faced with such a large group of learners, teachers of online open courses have to complete the assessment and their teaching tasks, which is a huge teaching burden. Therefore, in the context of the gradual maturation of educational assessment reform, the comprehensive introduction of peer assessment into online open courses has become a vital component of assessing learners' learning behavior in online open courses.

In the process of global transformation from simple lecture education to the whole process education (lecture-interaction-assessment), playing a central role in guiding learning assessment is essential to develop learners' core learning literacy, improve their learning skills, and avoid simple educational administrative means to interfere with learners' willingness to learn. More educational administrations and the teacher are also fully aware that learning assessment can effectively promote learners' learning engagement behaviors and learning performance. Many research documents show that student engagement can directly or indirectly affect learning performance. However, in online learning, learners' acceptance of high-quality, meaningful assessment from peers gradually develop, especially in online open courses, and peer assessment affects learners' motivation. Traditional peer assessment is usually conducted face-to-face in group pairs under the guidance of a teacher. Learners are prone to high levels of anxiety and tension, which affect the actual effectiveness of peer assessment. Thus, peer assessment in IT classrooms as an implementation tool for teaching reform can bring new innovative attempts and breakthroughs in education and improve learning efficiency and engagement.

2 Theoretical background and hypothesis development

Student engagement is widely defined as an active learning behavior, which is well recognized in Europe, America, and other developed countries and has a vital position in education. Much research has been conducted since the 1990s. The vast majority of the literature consistently supports the idea that student engagement has a significant

positive contribution to learning performance. Regarding how learning engagement affects learning performance, Chen [1] explored the relationship between self-efficacy and learning performance and engagement as a mediator of this relationship. The results showed that learning engagement was positively related to learning performance. Fisher et al. [2] analyzed the results of 348 questionnaires, and the findings indicated that flipped and blended learning approaches enhance learning engagement and ultimately positively affect perceptions of engagement, performance, and satisfaction. Nelson et al. [3] explored preschoolers' executive control (EC) as a predictor of learning engagement behavior in Grade 1. The results suggest that early EC may support subsequent classroom engagement behaviors critical to a successful transition to elementary school and long-term learning trajectories. Nkhoma et al. [4] collected data from 400 undergraduate students through an online questionnaire and used structural equation modeling for testing causal models. The results showed that the case study positively impacted students' skills and emotional engagement. Carini et al. [5] explored the relationship between student engagement and learning performance. The results of their questionnaire survey of 1058 students at a university showed that student engagement was positively associated with learning outcomes, but the correlations were weak.

Blasco-Arcas et al. [6] showed that, in online learning, teacher-student interactivity and students' engagement in learning are key potential forces in explaining the positive effects of improving student performance. The findings suggest that high levels of interaction positively influence positive collaborative learning and engagement, which improves student performance. Kusuma et al. [7] obtained data from 63 Grade 12 students, where 29 students are in the experimental group and 34 students are in the control group, defining student engagement as including behavioral, cognitive, and emotional involvement. Bergdahl et al. [8] concluded that high-performing students developed strategies to use digital technology in a supportive and productive manner.

Peer assessment refers to the process in which learners assess the learning outcomes of other peers in the same learning environment using the unified assessment criteria set by the teacher as a guide, that is, the process in which learners assess and are assessed by each other [9-10]. Peer assessment results from careful design and implementation by educated researchers or teachers [11]. They have a clear purpose of helping students progress. Peer assessment is only one type of classroom practice activity, an enrichment of classroom activities rather than a fundamental change in teaching methods [12-13]. Students' recognition of and motivation to participate in the classroom depends on how the teacher arranges the classroom activities, and the teacher's attitude will largely influence the students' attitude [14]. Compared with passive learners, autonomous and active learners are better adapted to the future society, and activities such as peer assessment positively affect the development of such learners [15]. Topping [16] showed that peer assessment helps students aid one another in planning their learning, identifying their strengths and weaknesses, targeting areas for remedial action, and developing metacognitive and other personal and professional skills. Hunter and Russ [17] introduced peer assessment in the context of a three-year follow-up at the University of Ulster. The results showed that peer assessment was indeed effective in enhancing learning performance. Sluijsmans et al. [18] analyzed the impact of peer assessment

training on student-teacher performance, and data analysis showed that the experimental group exceeded the control group in the quality of assessment skills. As a result of the training, students in the experimental group also scored significantly higher on the final product of the course than students in the control group. Double et al. [19] assessed the impact of peer assessment on the learning performance of primary, secondary, or tertiary students across subjects and domains and showed that peer assessment improved learning performance and that the validity of peer assessment was robust in a wide range of contexts. Xiao and Lucking [20] selected 232 predominantly undergraduate students for an experimental study. The results show that students in the experimental group were more satisfied with peer assessment methods than the control group in terms of peer assessment structure and peer feedback, using Wiki interactive software, and providing an online collaborative learning environment to facilitate peer assessment and thus add value to peer assessment. Li and Gao's [21] data analysis suggests that the impact of peer assessment on students' lesson plan items appears to vary by student learning level, with low and average achieving students showing significant improvements, but the model appears to have less impact on the performance of high achieving students. Blom and Poole [22] suggested that peer assessment impacts enhancing the breadth of learners' musical attention. Schönrock-Adema et al.'s [22] peer assessment in undergraduate medical education positively impacts professional behavior and is especially effective only after students have adapted to a complex learning environment.

The author summarized the above literature and concluded that student engagement could be composed of three elements: behavioral, affective, and cognitive engagement. Thus, the following four hypotheses are proposed in this study.

- H1: Behavioral engagement can significantly contribute to learning performance.
- H2: Affective engagement can significantly contribute to learning performance.
- H3: Cognitive engagement can significantly contribute to learning performance.
- H4: Peer assessment plays a moderating role in student engagement, significantly contributing to learning performance.

3 Methodology

3.1 Study subject

Shandong, a developed province in eastern China, released the "Education Informatization 2.0 Action Plan (2019–2022) of Shandong Province," which is currently used to promote the application of 5G technology in the construction of wireless campuses. The study subject is a regular provincial university in Jinan, Shandong Province, which has realized that all students have portable mobile learning terminals. The popularized digital libraries, creative spaces**,** recording classrooms, digital laboratories, virtual simulation training centers, and campus TV stations promoted the construction of smart logistics, security, and venues. They established a campus-sensing environment based on the Internet of Things and comprehensively built a smart campus environment that supports ubiquitous learning. The authors' group used the WeChat QR code to

conduct the questionnaire using the Wenjuanxing platform (www.wjx.cn), and the subsequent calculation statistics were performed by SPSS22.0 software. A total of 286 questionnaires were distributed, 267 were collected, and 217 valid questionnaires were obtained after eliminating invalid questionnaires, with a valid recovery rate of 81.27%.

Table 1 shows that the proportion and distribution of male students in majors and grades are more balanced than female students because of the mechanical majors. The respondents have a good representation in the overall questionnaire.

Table 1. Results of descriptive statistics of questionnaire respondents

Name	Option	Frequency	Percentage (%)	Cumulative percentage (%)
Gender	Female	78	35.94	35.94
	Male	139	64.06	100
Major	Mechanical engineering	24	11.06	11.06
	Mechanical and electrical engineering	35	16.13	27.19
	Industrial design	84	38.71	65.9
	Mechanical process technology	29	13.36	79.26
	Mechanical design and manufacturing and automation	31	14.29	93.55
	Material forming and control engineering	14	6.45	100
College Grade	Freshman	54	24.88	24.88
	Sophomore	64	29.49	54.38
	Junior	49	22.58	76.96
	Senior	50	23.04	100
Total		217	100	100

3.2 Questionnaire design

For student engagement, a questionnaire designed by Fredricks [24] was used. The questionnaire states that student engagement can be a meaningful combination of behavioral, affective, and cognitive engagement. The scale includes 5, 6, and 8 subscales with 19 questions. This questionnaire is widely cited and authoritative and used to measure student engagement. As shown in Table 1, learning performance was measured using midterm grades for the course and final grades for the study period, respectively, translating learning performance into an interval range of 7-1 points according to Table 1. The number of actual assessments was used as a moderating variable in the analysis of this study for the peer assessment input. The survey respondents all had to take the course "Fundamentals of Mechanical Design," and the overall teaching quality of this course was relatively high. After each course lecture, learners are required to create relevant courseware based on the teaching content and submit it to the platform (Smart Vocational Education) within a specified period and then conduct peer assessment according to the specified time. Teachers provide specific scoring criteria before peer assessment. Learners are informed of the peer assessment assignment's start time and due date. Peer assessment assignments are worth 50% of the total grade. Failure to

participate in peer assessment after the learner has submitted the assignment directly affects the grade.

Table 2. Student learning performance transformation form

Grade	95-100	90-94	80-89	70-79	65-69	60-64	0-59
Actual Assessment No.	34-36	28-33	22-27	16-21	10-15	5-9	0-4
Transformation Grade	7	6	5	4	3	2	1

4 Results analysis

4.1 Reliability and validity test

As can be seen from Table 3, the overall reliability coefficient value of the questionnaire is 0.903, which is greater than 0.9, thus indicating a high quality of reliability of the data.

Table 3. Reliability and validity results

Variables	Question No.	Correction item-total correlation (CITC)	The α coefficient of the deleted item	Cronbach coefficient	Cronbach coefficient
Behavioral engagement	A1	0.802	0.845	0.887	0.903
	A2	0.762	0.855		
	A3	0.836	0.837		
	A4	0.593	0.892		
	A5	0.647	0.88		
Affective engagement	B1	0.419	0.94	0.911	
	B2	0.908	0.872		
	B3	0.861	0.881		
	B4	0.82	0.885		
	B5	0.811	0.887		
	B6	0.759	0.896		
Cognitive engagement	C1	0.736	0.731	0.788	
		C2	0.652	0.739	
		C3	0.74	0.732	
		C4	0.693	0.74	
		C5	0.657	0.743	
		C6	0.455	0.775	
		C7	0.427	0.78	
		C8	-0.074	0.856	

Table 4 shows that the KMO value of Bartlett's test is 0.857, corresponding to a *p*-value of 0.000, indicating favorable validity.

Table 4. KMO and Bartlett's test

KMO Value		0.857
Bartlett's test	Chi-squared approximation	3650.823
	Df	171
	p-Value	0.000

Table 5 shows that the diagonal lines in the table are the AVE square root values, and the remaining values are the correlation coefficients. For behavioral engagement, the AVE square root value of 0.801 is greater than the maximum value of the absolute value of the inter-factor correlation coefficient of 0.575, implying good discriminant validity. For effective engagement, the AVE square root value of 0.819 is greater than the maximum value of the absolute value of the inter-factor correlation coefficient of 0.575, implying good discriminant validity. For cognitive engagement, the AVE square root value of 0.620 is greater than the maximum value of the absolute value of the inter-factor correlation coefficient of 0.522, implying good discriminant validity. Therefore, the questionnaire on student engagement shows good discriminant validity.

Table 5. Discriminant validity: Pearson correlation and AVE square root value

	Behavioral engagement	**Affective engagement**	**Cognitive engagement**
Behavioral engagement	0.801	-	-
Affective engagement	0.575	0.819	-
Cognitive engagement	0.372	0.522	0.620

4.2 Regression analysis

In Table 6, correlation analysis was used to examine the correlations between final learning performance and three items, behavioral, affective, and cognitive engagement, using Pearson correlation coefficients to indicate the strength of the correlations. Specific analysis shows that all items between final learning performance and behavioral, affective, and cognitive engagement show significant correlation with correlation coefficient values of 0.432, 0.333, and 0.442, respectively. The correlation coefficient values were greater than 0, implying a positive relationship between final learning performance and behavioral, affective, and cognitive engagement.

Table 6. Correlation coefficient table

	Average	**Standard deviation**	**Final Learning performance**	**Behavioral Engagement**	**Affective Engagement**	**Cognitive Engagement**
Final learning performance	4.613	1.4	1	-	-	-
Behavioral engagement	4.576	1.056	0.432**	1	-	-
Affective engagement	4.515	1.003	0.333**	0.575**	1	-
Cognitive engagement	4.562	0.86	0.442**	0.372**	0.522**	1

Note: * $p<0.05$ ** $p<0.01$

Table 7 shows that linear regression analysis was conducted with behavioral, affective and cognitive engagement as independent variables, and learning performance as the dependent variable. The multicollinearity of the model is tested, and all the VIF values in the model are less than 5, implying no covariance issue. The D-W value is approximately 2, thus indicating that the model is not autocorrelated. No correlation is found between the sample data, and the model is favorable. The final specific analysis reveals the following:

Table 7. Linear regression results

	Regression coefficient	**95% CI**	**VIF**
Constant	0.332 (0.676)	−0.632 – 1.296	-
Behavioral Engagement	0.428** (4.518)	0.242 – 0.614	1.509
Affective Engagement	−0.039 (-0.359)	−0.252 – 0.174	1.786
Cognitive Engagement	0.547** (4.903)	0.328 – 0.766	1.389
Sample	217		
R^2	0.279		
Adjustment R^2	0.269		
F Value	F (3,213)=27.451, p=0.000		
D-W Value: 2.151			

* p<0.05 ** p<0.01, t values in parentheses

Hypothesis H1 was verified. The regression coefficient value of behavioral engagement is 0.428 (t=4.518, p<0.01), implying that it will have a significant positive relationship with learning performance. When learners are in an online open course, once they adopt one another's peer assessment behavior, their behavioral engagement is more positive and obvious, and their self-efficacy in online learning is more prominent. Most learners have largely achieved shallow participation once they have completed peer assessment. As learners conduct online open courses over time and gain a deeper understanding of peer assessment, they become more proactive. Their behavioral engagement will shift from teacher-promoted assessment to self-initiated peer assessment. Therefore, in the future, when promoting the behavioral engagement of peer assessment, teachers should focus more on how to enhance the teaching strategies of learners' peer quality and effective peer assessment and encourage learners to complete assessment on time by giving extra points for it and real-time peer assessment in the classroom.

Hypothesis H2 was not verified. The regression coefficient value for affective engagement is −0.039 (t=−0.359, p>0.05), implying that it does not affect the relationship between learning performance. The main reason is that, on the one hand, the learners are unlikely to be pressured to learn online and are less concerned about others' learning performance. In online course learning, learners have a high degree of learning freedom. However, complex factors, such as different backgrounds, high privacy, low in-

structor supervision, low perceived constraints of learners, and high psychological security make learners in online open courses reluctant to assess other students. Such a situation can also lead to low credibility online peer assessment. On the other hand, learners do not develop a sense of knowledge reciprocity and transfer. Learners are more likely to give short-lived effective feedback on the peer assessment approach, without deeper effective engagement in their thinking. In particular, as the length of learning in online open courses extends, learners may experience a period of fatigue and reduce their sense of novelty, making their affective engagement more insignificant, affecting learners' learning performance less significantly.

Hypothesis H3 was verified. The regression coefficient value for cognitive engagement is 0.547 (t=4.903, $p<0.01$), implying that cognitive engagement exerts a significant positive relationship on learning performance. Learners' cognitive engagement significantly predicts learning performance. In particular, learners with higher cognitive engagement have higher levels of learning performance. The main reason is that learners have stronger cognitive feedback on online open courses, effectively promoting the construction of learners' knowledge systems. In particular, online open courses have some post-course assignments that need to be completed independently, and the learning-oriented cognitive engagement significantly affects the learning efficiency. Learners with higher cognitive engagement adopt more scientific learning styles and gradually form more efficient study habits, facilitating comprehensive mastery of knowledge, leading to improved performance. Learner peer assessment is an advanced cognitive activity in classifying cognitive goals, which can effectively facilitate meaningful learning in online contexts. High-grade learners tend to provide cognitive feedback because cognitive assessment is a higher category of learner assessment. Thus, good cognitive engagement can significantly improve learners' learning performance.

4.3 Mediating effect

Table 8 shows that the moderating effects are divided into three models. Model 1 includes the independent variable (student engagement). Model 2 adds the moderating variable (peer assessment engagement) to Model 1. Model 3 adds the interaction term (the product term of the independent and moderating variables) to Model 2. For Model 1, the aim was to investigate the effect of the independent variable (student engagement) on the dependent variable (learning performance) when the interference of the moderating variable (peer assessment engagement) was not considered. The above table presents that the independent variable (student engagement) shows significance (t=7.025, $p<0.05$), implying that student engagement has a significant impact on the learning performance relationship. The moderating effects can be viewed in two ways. The first is to view the significance of the change in F-value from Models 2 to 3. The second is to check the significance of the interaction term in Model 3. The moderating effects are analyzed. The table illustrates that the interaction term between student engagement and peer assessment engagement showed significance (t=1.994, $p<0.05$). Therefore, the magnitude of the effect of the moderating variable (peer assessment engagement) on learning performance varies significantly at different levels, as shown in the simple slope plot that follows.

Table 8. Results of analysis of moderating effects

	Model 1	**Model 2**	**Model 3**
Constant	4.613** (53.688)	4.613** (53.605)	4.617** (54.010)
Student Engagement	0.573** (7.025)	0.574** (7.027)	0.594** (7.265)
Peer Assessment Engagement	-	0.034 (0.581)	0.031 (0.533)
Student Engagement * Peer Assessment Engagement	-	-	0.110* (1.994)
Sample	217	217	217
R^2	0.187	0.188	0.203
Adjustment R^2	0.183	0.18	0.192
F value	F (1,215)=49.352, *p*=0.000	F (2,214)=24.768, *p*=0.000	F (3,213)=18.067, *p*=0.000
$\triangle R^2$	0.187	0.001	0.015
$\triangle F$ value	F (1,215)=49.352, *p*=0.000	F (1,214)=0.337, *p*=0.562	F (1,213)=3.976, *p*=0.047

Figure 1 shows that Hypothesis H3 was verified, students in online open courses should be guided to participate efficiently in the platform to obtain better online learning results. Engaging in peer assessment allows for more timely identification of motivated learners to complete the course. In the online learning environment, retaining traces of learning and enabling process analysis provides powerful support for teachers to capture the learning process. Therefore, based on learning analytics, learners who complete their first peer assessment are provided with appropriate support services to help them complete the course efficiently, improve task design for peer assessment, and increase timely feedback from teachers. To provide high-quality rubrics, teachers can provide assessment scales and specific forms to train learners on how to write rubrics. Meanwhile, the system platform should monitor promptly, increase feedback from the assessed on the rubric, and reward learners who provide valuable rubrics to promote learners' deeper participation in peer assessment from multiple perspectives. The visual feedback of the online peer assessment system facilitates teachers' understanding of learners' current status and enhances learners' perceptions in peer assessment, facilitating collaborative learning interactions, improving learners' sense of social presence, and regulating and disciplining learners' behavior.

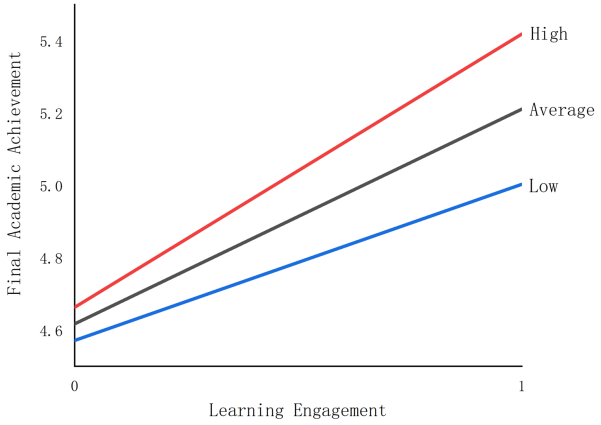

Fig. 1. Moderating effects diagram

4.4 Matched samples t-test

Table 9 shows a 0.01 significance (t=8.699, *p*=0.000) between final grade and midterm grade. Specific comparative differences show that the average final grade (4.61) is significantly higher than the average midterm grade (3.54). One set of the matched sample will all show variability. After the last half-semester of online learning, students became further familiar with the impact of online peer assessment on their grades after the half-semester of online open course familiarity. The peer assessment recommendation strategy can ensure the validity and reliability of results and promote students' learning communication and reflection. Thus, students are assessed more carefully, enhancing their enthusiasm for learning and improving their grades.

Table 9. Matched samples t-test analysis results

Matched (Average ± SD)		**Difference (Matched 1-Matched 2)**	**t**	**p**
Final grade	***Midterm grade***			
4.61±1.40	3.54±1.35	1.07	8.699	0.000**

* $p<0.05$ ** $p<0.01$

5 Conclusions

Online open courses are widely recognized for changing the traditional classroom teaching mode, getting rid of the limitation of time and space, and personalizing learning according to demands. Enhanced student engagement can promote self-adjustment and teachers' teaching improvement. Online peer assessment is an effective means to assess the learning effectiveness of online open courses. This study designed a questionnaire on the influence of student engagement on learning performance and analyzed

the role of peer assessment engagement as a moderating variable in the influence of student engagement on learning performance.

The following conclusions can be drawn that behavioral engagement can significantly contribute to learning performance. Cognitive engagement can contribute substantially to learning performance. Peer assessment plays a moderating role in student engagement, significantly contributing to learning performance. The average of students' final learning performance is considerably higher than that of midterm performance, showing significance at 0.01. Further research can be conducted on the assessment of the intelligence of peer assessment activities, the continuous tracking of learners' cognitive level in the process of peer assessment, the design of extrinsic or intrinsic incentives for peer assessment techniques, the improvement of the efficiency of peer assessment, and the standardization of language.

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