



Understanding teachers' online professional learning: A "community of inquiry" perspective on the role of Chinese middle school teachers' sense of self-efficacy, and online learning achievement

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ABSTRACT

Teachers' online professional development (PD) has been valued as a crucial and effective way to promote teaching competencies. Forming a professional learning community has been recognized as a means to promote effective PD. Within this realm of research, the Community of Inquiry (CoI) framework was deemed as a collaborative-constructivist process model that describes successful online learning experiences. The CoI has been associated with many psychological and educational variables, such as learning achievement and self-efficacy. This study leveraged on the CoI framework to assess teachers' online professional learning quality and explored its relationship with their self-efficacy and online professional learning achievement. A total of 456 teacher participants from Chinese middle schools participated in our study. A suite of questionnaires (the Community of Inquiry Questionnaire, the Teacher Efficacy Scale, and the Perceived Online Learning Achievement Scale) was distributed. Linear regression, PROCESS Macro mediation, and moderation analyses were run on the data to answer the research questions. Results revealed a significant relationship between teachers' online learning quality and their self-efficacy and learning achievement. The mediating roles of self-efficacy and learning achievement were confirmed. The moderating role of time spent on receiving online professional learning was also recognized. Implications and future directions were discussed.

1. Introduction

The existing literature has pointed to the fact that teachers' teaching quality exerts significant influences on students' learning outcomes [1]. Therefore, promoting teachers' professional development (PD) is crucial to improving their teaching skills, sense of professional identity, cognitive ability, and student attainment [2–8]. For instance, researchers offered evidence regarding the effect of teachers' professional learning on their self-efficacy and commitment [9]. Moreover, professional learning communities also affect teacher leadership in the Chinese educational context [10,]. However, some scholars argue that in-service teachers' continuous learning is seldom driven by oneself (e.g. Refs. [11,12]). Instead, institutional demands and peer influence are vital in motivating teachers to participate in professional learning activities [13,92]. Hence, considering such an extrinsically motivated nature of teachers

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participating in PD activities, it is imperative to evaluate the effectiveness of the professional learning process for the understanding and tracking of teachers' learning outcomes. One popular theoretical framework designed to offer guidelines for researchers to investigate learners' quality of learning is termed the Community of Inquiry (CoI). Nevertheless, no research to date has valued the CoI as a means of assessing teachers' online professional learning quality, not to mention fixating on the population of Chinese middle school teachers and attempting to connect the CoI with teachers' sense of efficacy. In filling this lacuna, the present research explored the relationship between Chinese middle school teachers' online professional learning effectiveness, sense of efficacy, and learning achievement within the CoI framework.

2. Literature review

2.1. Teacher professional development

Researchers have been devoting resources to probing teachers' professional development with various methods and topics. However, at the core of such endeavors, one should understand that teachers' professional development is equivalent to teachers' learning of the methodologies of learning and the capabilities of transferring such knowledge into their teaching practice [14,93]. The impetus of teachers' PD lies within the desiderative need to improve teachers' growth of expertise, elevating self-efficacy, and thus boosting job satisfaction and morale [15]. Consequently, continuous PD will equip teachers with the knowledge to cater to all students' needs, which will inevitably result in the growth of student competence and cognitive development, and learning achievement [16, 17].

The extant research has witnessed a shift of focus in the realm of PD exploration from attending to isolated teacher professional learning-related aspects to contextualized and sustained activities that are interactive, dynamic, and continuously developing processes [18–20]. For instance, in the Chinese PD context, most PD programs are offered by the Ministry of Education of the People's Republic of China [21]. Scholars have criticized that some programs offered to teachers are not meritorious representatives of teachers' preferences or concerns and the rapid development of the Chinese educational status [22–24]. Although participating in PD activities is stipulated by most schools and universities in China as obligatory, teachers' lack of incentives and impaired learning quality are inevitable outcomes [92]. Hence, to compensate for the aforementioned deficiency with the purpose of strengthening the effectiveness of teachers' PD experience and motivating teachers' participation, some scholars are calling for new designs of PD programs (e.g. Refs. [25,26]). A good example was offered by Zhang, Admiraal, and Saab [26]. They explored the personal and school-level factors that contribute to enhancing teachers' motivation for PD in a new PD program, the New Basic Education (NBE), and obtained positive relationships among the proposed variables. However, more research is needed to illustrate what effective PD entails.

A meta-analysis yielded six characteristics perceived as prerequisites of effective PD [27]. First, an effective PD is built upon consistent participation in PD activities and frequent use of PD resources [28]. It is even argued that PD activities should be actively held or passively received in a rhythmic fashion instead of sporadically and irregularly. The latent consideration is that teachers will need time to assimilate new knowledge [29]. Second, it is also implied that teachers' active endorsement of PD activities is perceived as more effective than obligatory participation [30], which is consistent with recognizing that high-quality teacher professional development should establish an inquiry-based and teacher-driven learning habit [31,32]. Third, subject-specific training activities or resources are preferred in contrast to general pedagogical techniques training [27]. PD should offer activities, courses, or resources to cater to the specific needs of teachers, such as their teaching goals and assessment techniques [33]. However, it is also argued that both subject-specific and general training are complementary and indispensable. Thus, receiving both trainings is vital to teachers' effective PD. Fourth, inviting extrinsic expertise is an effective way to promote teachers' PD rather than recycling familiar knowledge [30]. This is to pose challenges and fresh input for teachers. Fifth, PD will be more effective if teachers are allowed to practice what they have learned [28]. This is justified by the consideration that students' performance can be used to analyze the impact of PD and offer feedback and reinforcement [33]. Finally, it is stated that PD is more effective when teachers learn and work in a coordinated fashion [27,28]. In most cases, forming a learning community or peer group can be a decent practice. It enhances teachers' learning experience by presenting opportunities to challenge each other and offer unique insights into issues relevant to the community. Therefore, topics relating to the professional learning community have been extensively explored in the last three decades.

The notion of professional learning communities (PLC) is comprehended as the learning communities in which teachers collectively learn and work to form an atmosphere that embraces shared values, responsibilities, and professional learning practices to enhance teaching and learning [34]. It is often recognized, as stated above, as an approach to fostering effective PD. Empirical research has also confirmed the significant relationship between PLC and teachers' performance. For instance, PLC is identified to be related to teachers' self-efficacy (e.g. Ref. [35]), commitment (e.g. Ref. [36]), and job satisfaction (e.g. Ref. [37]). Consequently, such enhancement of teacher performance yields positive impacts on students' achievement [38]. According to McConnell and colleagues [39], a PLC should be designed to embody several components: shared values and vision, shared leadership, supportive conditions, shared practice, and collective learning and application of learning. Dufour [40] also emphasized that PLC should concentrate on learning and results that will exert consequences on student performance and, at the same time, create and maintain a culture of collaboration. Nevertheless, despite the effectiveness of PLC in improving teachers' PD, designing PLC to address all teachers' needs can be challenging. Teachers may need to consider multiple influencing factors before participating in PD programs, such as being enlisted in full-time and long-term intensive learning programs [41] and the demanding workload and family responsibilities [42]. Fortunately, with the advancement of technology in online education, new opportunities are presented to the design and application of PLC, which offer promising solutions for motivating more teachers to participate in PLC.

Creating online collaboration in PLC for curriculum development, peer interaction, assessment, problem-solving, and reflection is

one way to promote teacher participation in PD [43]. As mentioned earlier, effective PD relies heavily on teachers' consistent participation, active endorsement, and collective culture. These are also non-negligible characteristics for designing effective PLCs. Participating in online PLCs enables teachers to significantly recognize the support from others and the sharing of knowledge [44]. In their empirical study, Cifuentes and colleagues [45] illustrated that with continuous participation in online PLC, teachers gradually relied on technology integration and became fond of such forms of learning. Moreover, collaborating online with peers helped shift the instructional pattern from teacher-centered to student-centered. Finally, online PLCs can also foster digital integration, offering diversity in the classroom setting.

In sum, in reviewing the benefit of PD, PLC, and online PLC, we have to evaluate the quality or effectiveness of teachers' professional development activities organized in a collaborative community fashion.

2.2. The Community of Inquiry framework

According to Castellanos-Reyes [46], the Community of Inquiry (CoI) framework is "a collaborative-constructivist process model that describes the essential elements of a successful online higher education learning experience." Such a model emphasizes the factors contributing to the effective online higher education learning experience and the significance of developing a learning community. The impetus for focusing on this realm of research is the increasing number of online educational programs and the desire to strengthen student-teacher communication through online learning [47]. Hence, the Community of Inquiry framework was designed when transcribed online discussions were analyzed and results showed that they promoted student-instructor communication [48]. The Community of Inquiry framework comprises three elements of presence that are multidimensional and interdependent [49,50], which are cognitive presence (CP), social presence (SP), and teaching presence (TP). We review these next.

2.2.1. Cognitive presence

The connotation of cognitive presence implies learners' abilities to construct knowledge through discourse and reflection [48,51]. It values critical thinking as the goal of all educational experiences, which stemmed from Dewey's reflective thinking as a form of the generalization of the scientific method [52]. The Practical Inquiry Model was later framed based on Dewey's argument that reflective inquiry bears practical value [53] and operationalizes cognitive presence. According to this model, CP is a cycle of practical inquiry that describes an individual's active effort to progress the learning process from understanding the problem to exploration, integration, and application [54]. Thus, the Practical Inquiry Model embraces a four-phase inquiry process that begins with a triggering event when confronting a problem. Then, more information will be actively acquired for exploring the current issue. Following that, with the necessary information to understand the issue collected, a process of integration that connects the information will be executed, and attempts to search for viable explanations will be carried out. Finally, the most viable resolution will be selected. It is worth noting that such a process should not be witnessed as linear or discrete. Repetitions of any phase for new direction and new information may be required [53]. In the Community of Inquiry framework, cognitive presence is witnessed in online discussions. Research revealed that most online discussions orbit around the exploration phase of information sharing and searching for ideas but rarely move beyond this phase [47].

2.2.2. Social presence

The social presence factor of the CoI framework is conceptualized as the ability to establish purposeful interpersonal relationships to connect one to another in computer-mediated learning [55]. The core components of social presence are affectiveness (emotions expressed by learners), open communication (learners interact with others), and group cohesion (group commitment formed and sustained by group members) [56]. It arises from the concerns that online learning may hamper students from developing community/group belonging with their peers and instructors (e.g. Refs. [57,58]). Zydney, deNoyelles, and Seo [59] illustrated that students perceived online discussions to be more effective when included in the three aspects of social presence. In past research, scholars have delved into the social presence of the CoI framework independently of the other two presences. They found that the asynchronous nature of online learning could significantly affect learners' social lives [54]. Some scholars (e.g. Ref. [54]) even claimed that more research on the interaction of both social presence and cognitive presence be conducted. In response, Guo, Saab, Wu, and Admiraal [60] explored students' social and cognitive presences within the CoI framework in online project-based learning and the impact of two presences on academic performance.

2.2.3. Teaching presence

The cognitive and social aspects (or presences) of the educational process are viewed as equivalent processes that should be weighted with equal importance. However, one must also acknowledge that the purpose, structure, and leadership should also be valued, which describes the teaching presence of the Community of Inquiry framework [55]. Hence, teaching presence in the CoI framework is defined as "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" [61]. It serves as the role of foundation or support in the CoI framework as it offers the stage for the learning experience and creates the climate in which critical thinking is rooted [47]. Researcher have argued that the online learning environment challenges teaching presence [62]. New forms of communication may easily confuse students, and technology-related issues increase teachers' workload on maintaining the classroom environment and engagement with students. Inappropriate facilitation and compromised instruction techniques will inevitably result in damaged teaching presence. Ghaemi's [63] study of the effects of the Community of Inquiry model on Iranian students revealed a positive relationship between promoting the teaching presence elements and an enhanced sense of community.

The social, cognitive, and teaching presences function interdependently and affect learners' learning experiences with each of its components taken into account. In the CoI framework, the intersection and interaction of the three presences are clearly visible and that learners' optimal educational experiences originate from the intersection of all the presences (see Fig. 1.).

Research connecting the three presences is not unprecedented. For instance, Xu, Li, and Luo [64] examined the potential influencing factors of social, cognitive, and teaching presence in China by conducting a national survey. They reported that self-regulated learning and self-efficacy are significant influential factors of the three presences. Moreover, a study by Hong and Kim [65] verified the relationship between social presence, cognitive presence, and online learning satisfaction and revealed a positive relationship among them.

The primary application of the Community of Inquiry framework to the understanding of educational experience targets students. The evaluation and understanding of teachers' professional development from the CoI framework are scant. Only a few studies are available. For instance, Knudsen [66] conducted a mixed-method study and revealed a relationship between social, cognitive, and teacher presence of the CoI framework and teachers' perceptions of learning in a blended professional learning environment when an online course incorporated all three presences. In light of this deficiency, the present research seeks to apply the Community of Inquiry framework to assess the middle school and high school teachers' online learning experiences and explore the interaction with their sense of efficacy and perceived learning achievement.

2.3. The role of teacher self-efficacy

As an essential construct of motivation, teacher efficacy (or self-efficacy) belief is a judgment of one's capabilities to exert a desired influence on students' engagement and learning achievement [67]. Thus, it is often connected with students' engagement, motivational beliefs, and academic achievement (e.g. Refs. [68,69]). Past research has identified four sources that affect teachers' self-efficacy. First, mastery experience, as the preferable way to acquire new skills, improve performance, and teach oneself to be capable of learning new skills, serves as an indicator of capabilities [70]. Successful performance generates increased self-efficacy, while setbacks damage it. Mastery experience is gradually constructed with the increase of self-efficacy, and such experience will, in return, be used to reinforce the promotion of self-efficacy. The vicarious experience is the second source of developing potent self-efficacy provided by social models [71]. Social comparison and observation allow individuals to acquire vicarious experience, which substantially enhances self-efficacy, especially when individuals doubt their capabilities [72]. The third source of self-efficacy development is the social persuasion. Such a source draws benefit from the encouragement of individuals' trusted friends and family members by being persuaded to believe in themselves [73], albeit social persuasions are deemed as less effective compared with mastery and vicarious experiences in promoting self-efficacy [70,71]. Finally, the physiological state (or emotional arousal) is another way to develop self-efficacy by reducing negative emotions that can potentially harm one's self-efficacy and improving physical condition [74,75].

As a basic psychological construct, self-efficacy plays a vital role in maintaining a high quality of life and promoting learning and working performance, regardless of individuals' social status and profession. In education, the development of teachers' self-efficacy has been given substantial attention. Teachers with a strong sense of efficacy exhibit more subjective initiatives and enthusiasm for teaching, are more effective and organized, and tend to be more resilient when facing obstacles [69,76]. Hence, scholars have recently been delving into the relationship between teacher self-efficacy, professional development, and the learning community.

As mentioned earlier, receiving professional development (PD) and participating in professional learning communities (PLC) is vital to enhancing teachers' teaching skills, work engagement, and student learning performance. Research has also revealed that PD

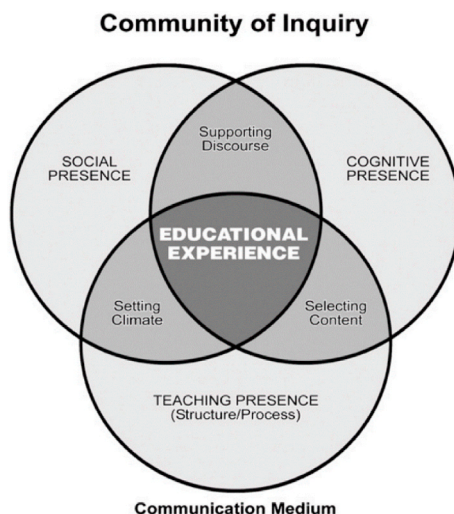


Fig. 1. Community of Inquiry framework from Garrison and Arbaugh [47].

and PLC profoundly influence teachers' self-efficacy. For instance, Zonoubi, Rasekh, & Tavakoli [77] conducted a longitudinal study exploring the impact of six-month PLC interventions on EFL teachers' self-efficacy. Results revealed that experienced teachers exhibited improved self-efficacy in applying new teaching strategies, and novice teachers reported enhanced self-efficacy relating to classroom management, autonomy, and perceived language proficiency. Similarly, as mentioned earlier, Zheng, Yin, and Liu [9] also reported that reflective dialogue in school-level PLC significantly predicted teachers' self-efficacy. Moreover, teachers' self-efficacy was also found to impact teachers' professional learning experiences. For instance, Kılınc, Polatcan, Atmaca, & Koşar [78] illustrated that teachers' self-efficacy positively and significantly predicted their academic optimism and professional learning.

Considering its importance in the realm of education, teacher self-efficacy has been and should be regarded as a crucial factor connecting many other psychological and educational variables. The above literature sheds some light on this consensus. Hence, the present research also embedded teacher efficacy into the model.

3. The present study

From the above literature review, it is evident that no research to date has applied the Community of Inquiry framework to assess Chinese middle school teachers' online professional learning experience and has attempted to connect it with teacher efficacy and professional learning achievement. The present research was designed to fill this academic lacuna. The primary purpose of the present research was to understand the potential impact brought by teachers' online professional learning activities on their sense of efficacy and professional learning achievement. More specifically, we addressed the following research questions:

- (1) How does a teacher's assessment of the quality of the online learning experience affect their sense of efficacy and learning achievement?

Table 1
Demographic information of the participants.

Demographic Information Category	N	%
Gender		
Male	139	31.7
Female	300	68.3
Total	439	100
Age		
20–33	141	32.1
34–41	156	35.6
42–59	142	32.3
Total	439	100
Level of Education		
Less than high school degree	1	.2
High school degree	1	.2
College degree	13	3.0
Bachelor's degree	353	80.4
Master's degree	68	15.5
Doctoral degree	3	.7
Total	439	100
Teaching Subjects		
Chinese literature	64	14.6
Math	59	13.4
English	171	39.0
Physics	25	5.7
Chemistry	21	4.8
Biology	28	6.4
Politics	19	4.3
History	16	3.6
Geography	16	3.6
Others	20	4.6
Total	439	100
Teaching Experience (year)		
0–10	166	37.8
11–21	148	33.7
22–40	125	28.5
Total	439	100
Teaching Grades		
1st to 2nd grade	16	3.6
3rd to 4th grade	8	1.8
5th to 6th grade	13	3.0
7th to 9th grade (middle school)	203	46.2
10th to 12th grade (high school)	199	45.3
Total	439	100

- (2) Does a teacher's sense of efficacy mediate the relationship between assessment of the online learning community and perceived learning achievement?
- (3) Does the teacher's perceived learning achievement mediate the relationship between assessment of the online learning community and sense of efficacy?
- (4) Will spending more time on online professional learning activities strengthen the effect of learning quality on teachers' perceived learning achievement?

4. Methods

4.1. Participants

We recruited a convenience sample comprising 456 teacher participants from 20 middle schools across China. Regarding the process of applying for ethical approval, it should be noted that there was no existing institutional review board at Henan University. In light of this, the School of Foreign Languages proactively established an institutional review board in response to our request (the School of Foreign Languages Institutional Review Board). Subsequently, this newly organized review board thoroughly reviewed and approved our ethics application (No. IRBFL2022041901). Upon their approval, we implemented the data collection procedure. All participants voluntarily took part in this study anonymously, and informed consent was obtained from all participants. Upon preliminary data cleaning, we obtained a total of 439 valid cases with reference to the selection criteria. Those reported to have fewer than 18 years of teaching experience were excluded. In the end, 139 males (31.7%) and 300 females (68.3%) were retained in our study, with their ages ranging from 20 to 59 years old ($M = 38.17$, $SD = 8.57$). Table 1 gives details about these participants.

4.2. Instruments

4.2.1. The Community of Inquiry questionnaire

To assess participants' assessment of their online professional learning experience, we adopted the Community of Inquiry (CoI) framework survey developed and validated by Arbaugh and colleagues [79]. As reviewed in the literature review section, the structure of the Community of Inquiry framework comprises three independent and yet intertwined constructs, namely, cognitive presence, social presence, and teaching presence. The CoI survey instrument was designed to accurately reflect these factors. Thirty-four items were created with items one to 13 loaded on the teaching presence factor (Cronbach $\alpha = 0.94$ from Arbaugh and colleagues' work), items 14 to 22 loaded on the social presence factor (Cronbach $\alpha = 0.91$), and items 23 to 34 loaded on the cognitive presence factor (Cronbach $\alpha = 0.95$). Sample items are "The instructor clearly communicated important course goals" (Teaching presence), "I was able to form distinct impressions of some course participants" (Social presence), and "I felt motivated to explore content related questions" (Cognitive presence). The CoI instrument was translated from English to Chinese by an English major graduate student. All items were answered on a five-point Likert scale from 0 (strongly disagree) to 4 (strongly agree). The reliability of the translated instrument is shown to be excellent (Cronbach $\alpha = 0.98$ for the overall scale).

4.2.2. The teacher efficacy scale

The Teacher Efficacy Scale used to assess teachers' self-efficacy for the present study was adapted from the work by Tschannen-Moran and Hoy [76]. The authors developed a 24-item scale measuring teacher self-efficacy from three dimensions: Efficacy for instructional strategies (Cronbach $\alpha = 0.91$), efficacy for classroom management (Cronbach $\alpha = 0.90$), and efficacy for student engagement (Cronbach $\alpha = 0.87$). Items 1 to 8 loaded on the instructional strategies factor, 9 to 16 loaded on the classroom management factor, and 17 to 24 loaded on the classroom management factor. Nevertheless, despite the high reliability of the 24-item scale, Tschannen-Moran and Hoy [76] further pushed up the scale's reliability. They selected the four items with the highest loadings from each dimension, leaving a 12-item short version of the teacher efficacy scale. The factor structure remained intact, and the three dimensions still exhibited high reliabilities: 0.86 for instructional strategies, 0.86 for classroom management, and 0.81 for student engagement. The present study adapted and translated the 12-item version of Tschannen-Moran and Hoy's scale to situate the instrument in the Chinese middle school teaching context. Participants answered the items in a 9-point fashion, with anchors at 1 (nothing), 3 (very little), 5 (some influence), 7 (quite a bit), and 9 (a great deal). Sample items are "To what extent can you use a variety of assessment strategies?" (Instructional strategies), "How much can you do to get children to follow classroom rules?" (Classroom management), and "How much can you do to help your students value learning?" (Student engagement). Test results for internal consistency of the overall instrument from the present research exhibited excellent reliability (Cronbach $\alpha = .95$).

4.2.3. The Perceived Online Learning Achievement Scale

To measure teachers' perceived online learning achievement, we utilized the scale developed by Ramos-Pla and colleagues [80], which was designed to inquire about Catalan universities professors' perceptions of the impact of online training. The original scale consists of 6 blocks with 51 items in total, which include: the type of training received (block 1: 9 items), level of learning derived from the training (block 2: 8 items), help from the knowledge acquired (block 3: 12 items), feelings towards the use of the new knowledge (block 4: 4 items), difficulties in the application of the training received (block 5: 9 items), and perceptions of the impact of the training (block 6: 9 items). From the six sub-scales, we deem the items from block three best fit our need to examine teachers' perceived online learning achievement as the original items from this block directly question participants' gains from online training. As the original scale by Ramos-Pla and colleagues [80] was created specifically for the participants from Catalan universities, we modified and

translated the items in block 3 to situate the scale into the present research context. Participants answered the questions on a five-point Likert scale ranging from 0 (nothing) to 4 (a lot) and were instructed to indicate how much their experience of online learning activities and use of online learning resources helped their teaching experience. Sample items are “Improve the quality of my teaching” and “Have more knowledge about methodologies that are adequate for teaching.” A 0.99 Cronbach’s Alpha score was witnessed in the present study, signaling excellent reliability of the scale.

4.3. Data collection procedure

A convenient sampling strategy was exploited, and the suite of questionnaires was distributed online via the Wenjuanxing.com platform, a popular and sophisticated Chinese online website that excels in questionnaire design and distribution. The link to the questionnaires generated from the platform was later shared with our participants via WeChat, one of the most popular Chinese social media platforms. Detailed instructions on how to respond to each questionnaire item were provided for each instrument. Prior to accessing the survey, participants were presented with a consent form, informing their rights of participation and withdrawal and ensuring their anonymity. Only those who gave explicit consent were granted access to the questionnaires. Finally, upon completing the questionnaires, participants were offered a small token of appreciation (3 RMB) for their participation. The data collection procedure took three months, from May 2022 to August 2022.

5. Results

Descriptive statistics for the variables are presented in [Table 2](#).

It is evident that participants reported relatively high perceptions of learning quality, sense of efficacy, and learning achievement.

5.1. The relationship between learning quality, achievement, and sense of efficacy

A simple linear regression was conducted to explore the potential relationship between teachers’ learning quality reflected by the Community of Inquiry score (CoI) and their sense of efficacy. The scatterplot revealed a strong positive linear relationship between the two. A Pearson’s correlation coefficient of .32 ($p < .001$) confirmed the result. A significant relationship between teachers’ learning quality and sense of efficacy was identified from the result of simple linear regression ($F(1,437) = 50.18, p < .001$) shown in [Table 3](#). Teachers’ self-efficacy level increased by 0.23 for each unit increase in online learning quality. The R^2 value was 0.10, suggesting that 10% of the variation in teachers’ sense of efficacy can be explained by learning quality.

Another simple linear regression was applied to reveal the relationship between teachers’ learning quality (CoI) and their perceived learning achievement. The scatterplot also revealed a strong positive linear relationship between the two and was confirmed by a Pearson’s correlation coefficient of .61 ($p < .001$). A significant relationship between teachers’ learning quality and perceived learning achievement was identified from the result of simple linear regression ($F(1,437) = 257.81, p < .001$) shown in [Table 4](#). Teachers’ perceived learning achievement level increased by 0.31 for each unit increase in online learning quality. The R^2 value was 0.37, suggesting that 37% of the variation in teachers’ perceived learning achievement can be explained by learning quality.

To sum up, results from two simple linear regressions confirmed the positive effects of teachers’ perceived learning quality on their sense of efficacy and learning achievement, implying that the quality of the online learning community plays a vital role in enhancing teachers’ sense of efficacy and their professional learning achievement.

5.2. The mediating role of perceived learning achievement and teachers’ sense of efficacy

5.2.1. Perceived learning achievement as the mediator

For the purpose of investigating the role of perceived learning achievement in the effect of online learning quality on teachers’ sense of efficacy, a mediation analysis was performed using the PROCESS Macro add-on in SPSS. The outcome variable for analysis was teachers’ sense of efficacy. The predictor variable was teachers’ evaluation of online learning quality. And the mediator for the analysis was teachers’ perceived learning achievement. The results showed that online learning quality significantly affected teachers’ sense of

Table 2
Descriptive statistics.

Variables	Male	Female	Grade				
			1st to 2nd	3rd to 4th	5th to 6th	7th to 9th	10th to 12th
Learning quality (CoI)	126.15 (26.47)	132.82 (19.17)	139.38 (17.61)	139.13 (20.60)	130.15 (15.50)	133.94 (18.62)	126.46 (24.91)
Sense of efficacy	81.29 (16.64)	82.32 (15.41)	80.00 (18.44)	84.00 (15.88)	78.15 (12.67)	82.61 (15.18)	81.70 (16.46)
Perceived learning achievement	45.05 (12.19)	46.99 (10.75)	50.31 (10.66)	48.50 (11.60)	45.77 (10.03)	47.41 (10.79)	44.95 (11.73)
Time spent on online learning	134.36 (357.29)	121.13 (363.88)	203.00 (423.38)	959.00 (1252.69)	145.27 (202.96)	112.89 (250.72)	112.51 (402.54)

Note: Values represent mean score (Standard deviation).

Table 3
Regression (X = Community of Inquiry score; Y = Sense of Efficacy).

	Sum of Squares	df	Means Square	F	Sig.	R ²	Adjusted R ²	Durbin-Watson
Regression	1126.08	1	1126.08	50.18	.00	.10	.10	2.02
Residual	98067.91	437	224.41					
Total	109327.99	438						
	Unstandardized Coefficients		Standardized Coefficients					
	b	SE	β	t	Sig			
Constant	51.79	4.32		11.98	.00			
Col	.23	.03	.32	7.08	.00			

Table 4
Regression (X = Community of Inquiry score; Y = Perceived Learning Achievement).

	Sum of Squares	df	Means Square	F	Sig.	R ²	Adjusted R ²	Durbin-Watson
Regression	20599.71	1	20599.71	257.81	.00	.37	.37	2.24
Residual	34917.03	437	79.90					
Total	55516.73	438						
	Unstandardized Coefficients		Standardized Coefficients					
	b	SE	β	t	Sig			
Constant	5.51	2.58		2.14	.03			
Col	.31	.02	.61	16.06	.00			

efficacy ($E = .231, SE = 0.038, p < .001$). The results of indirect effects also yielded significant relationships between online learning quality and perceived learning achievement ($E = 0.313, SE = 0.020, p < .001$) and between perceived learning achievement and teachers' sense of efficacy ($E = 0.663, SE = 0.074, p < .001$). These results highlight that perceived learning achievement significantly mediates the relationship between online learning quality and sense of efficacy [$E = .207, SE = 0.028, C.I. (0.1558, 0.0168)$] (see Fig. 2 for the model coefficient diagram). Results from the Sobel test also confirmed the successful mediating effect ($E = 0.207, SE = 0.026, Z = 7.831, p < .001$). Hence, it can be concluded from the results that the quality of a good online learning community can enhance teachers' sense of efficacy. This phenomenon can be explained, to a certain degree, by teachers' perceived learning achievement.

5.2.2. Teachers' sense of efficacy as the mediator

Similarly, to probe into the role of teachers' sense of efficacy in the effect of online learning quality on teachers' perceived learning achievement, a mediation analysis was performed again using the PROCESS Macro add-on in SPSS. The outcome variable for analysis was teachers' perceived learning achievement. The predictor variable was teachers' evaluation of online learning quality. And the mediator for the analysis was the teachers' sense of efficacy. The results showed that online learning quality significantly affects teachers' perceived learning achievement ($E = 0.313, SE = 0.020, p < .001$). The results of indirect effects also yielded significant relationships between online learning quality and teachers' sense of efficacy ($E = 0.231, SE = 0.033, p < .001$) and between teachers' sense of efficacy and perceived learning achievement ($E = 0.236, SE = 0.023, p < .001$). These results highlight that teachers' sense of efficacy is a significant mediator in the relationship between online learning quality and perceived learning achievement [$E = .055, SE = 0.013, C.I. (0.0330, 0.0847)$] (see Fig. 3 for the model coefficient diagram). Results from the Sobel test also confirmed the successful mediating effect ($E = 0.055, SE = 0.010, Z = 5.542, p < .001$). Hence, it can be concluded from the results that a good online learning community quality can promote teachers' learning achievement. To a certain degree, this phenomenon can be explained by teachers' sense of efficacy.

5.3. The moderating role of time spent on online learning

A moderation analysis was conducted using the PROCESS Macro add-on in SPSS to explore the role of time spent in online learning quality in affecting teachers' perceived learning achievement. The outcome variable for the analysis was teachers' perceived learning

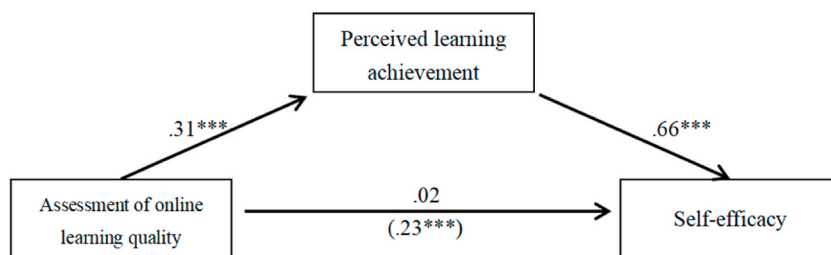


Fig. 2. Mediation coefficient diagram (Learning achievement as the mediator). Note. *** $p < .001$.

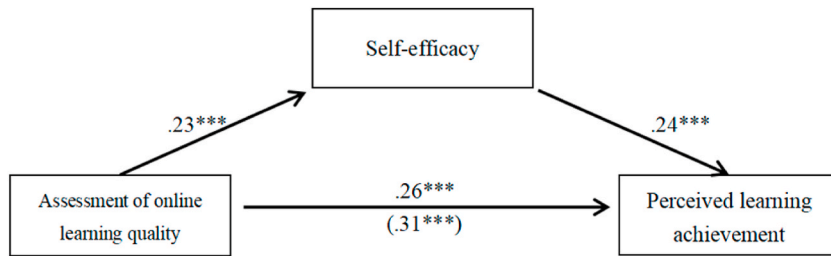


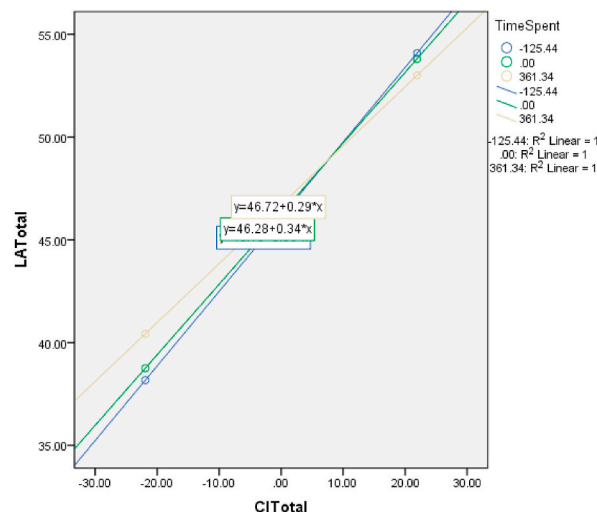
Fig. 3. Mediation coefficient diagram (Self-efficacy as the mediator).

achievement. The predictor variable was perceived online learning quality reflected by the Community of Inquiry score. The moderator variable for the analysis was the approximate time teachers spent receiving online professional development education or using online professional learning resources in the last 12 months. The interaction between time spent in online learning and online learning quality was statistically significant [$B = -0.0002$, 95%C.I. $(-0.0002, -0.0001)$, $p < .001$]. The conditional effect of online learning quality on perceived learning achievement at values of learning time also revealed corresponding results. At a low moderation level (learning time = -125.4389), the conditional effect was 0.3632 [C.I. $(0.3218, 0.4047)$, $p < .001$]. At middle moderation level (learning time = 0.0000), the conditional effect was 0.3436 [C.I. $(0.3044, 0.3827)$, $p < .001$]. At a high moderation level (learning time = 361.3424), the conditional effect was 0.2869 [C.I. $(0.2427, 0.3310)$, $p < .001$]. These results identify time spent in online learning as a negative moderator of the relationship between online learning quality and perceived online learning achievement (see Graph 1). In other words, the less time teachers spend in online professional learning activities, the more intense the impact of online learning quality on perceived learning achievement.

6. Discussion

6.1. Direct relationships

The results of the present study offered us insight into the quality of online professional learning that bears significant influences on Chinese middle school teachers' sense of efficacy and learning achievement. First, a significant positive relationship was confirmed between teachers' online professional learning quality (assessed by the instrument built upon the Community of Inquiry framework) and perceived learning achievement. A possible justification of this relationship is that better quality of online professional learning should promote teachers' learning achievement by offering more enriched learning content, a tension-free learning environment, and meaningful communication among peers. This research finding is consistent with what was reported in existing studies. For instance, work by Choy and Quek [81] unveiled the direct positive relationship between cognitive presence within the CoI framework and academic-related online performance and achievement. Similar findings from the study by Maddrell, Morrison, and Watson [82] also confirmed the significant positive relationship between each of the presences of CoI framework and student-perceived learning. Nevertheless, the authors have also reported that no relationship was identified between the CoI composite score and students' learning achievements; only the cognitive presence exhibited a significant positive relationship with learning achievement. However,



Graph 1. Simple slope analysis graph for moderation analysis. Note. CI represents the Community of Inquiry; LA represents learning achievement.

these findings do not decisively remove the possible relationship between CoI and learning achievement. Maddrell and colleagues' work [82] employed instructors' subjective assessments of critical projects or papers in the course as measurements of students' learning achievement. The present study adopted a self-report fashion to reflect learning achievement.

Secondly, a positive relationship was also identified between teachers' assessment of online learning quality and their sense of efficacy. Such a result could possibly be justified by the influence that better quality of online professional learning should promote students' engagement in the study and learning achievement, thus resulting in enhanced self-efficacy. Past research discussing such a relationship was also prolific. Some scholars argued that self-efficacy is a potent predictor that affects learners' perceptions of Community of Inquiry factors. For instance, Shea and Bidjerano [83] reported that learners' self-efficacy predicted effort regulation, which yielded favorable perceptions of cognitive presence. Conversely, applying the CoI framework as guidance for course design was also found to generate positive influences such as enhancing self-efficacy. Brennan, Packard, and Newman [84] reported that asynchronous courses designed using the CoI framework to push learners' thinking about culturally responsive pedagogy witnessed positive shifts in learners' perceived self-efficacy over the year. In reviewing the literature, we found that research revolving around the CoI framework and self-efficacy either posits self-efficacy as a variable leading to changes in the three presences of CoI or explores the impact of the classroom environment guided by the CoI framework on learners' self-efficacy. Recognizing the CoI framework as a means to assessing learners' online learning quality and explore its relationship with self-efficacy and learning achievement is the innovative consideration of the present research, not to mention the selection of Chinese middle school teachers as our sample and teacher professional development as the background.

6.2. Mediation and moderation

We speculated that the relationship between online professional learning quality assessment, self-efficacy, and learning achievement might not be straightforward. Hence, self-efficacy and learning achievement were separately explored as potential mediators in the model. The results confirmed our hypothesis. Self-efficacy significantly mediated the relationship between the assessment of online professional learning and perceived learning achievement. Such a finding implies that improving online learning achievement through the betterment of online professional learning quality is the consequence of elevated self-efficacy on account of better online learning quality.

The hypothesized mediational role of self-efficacy in the CoI and learning achievement model is not groundless. The mediating role of self-efficacy in Community of Inquiry research is supported by past research. For instance, Shea and Bidjerano's work [83] also confirmed the partial mediating role of self-efficacy in the links between teaching presence, social presence, and cognitive presence. Moreover, a study by Yandra and colleagues [85] revealed that online learning self-efficacy (OLSE) fully mediated the relationship between teaching presence and students' satisfaction. OLSE also partially mediated the relationship between social presence and students' satisfaction and the relationship between cognitive presence and students' satisfaction. As for the hypothesis of the present research, as discussed above, we uncovered a significant positive relationship between teachers' perception of learning quality (CoI) and self-efficacy. Although not viewing the CoI framework as a method to represent perceived learning quality, the work by Brennan and colleagues [84], as mentioned above, also supported the result from the present research. On the other hand, it is needless to explicate its influence when referring to the impact of self-efficacy on learning achievement. Numerous studies have been devoted to this realm of research. For instance, Bouih, Nadif, and Benattabou [86] reported in their article that self-efficacy significantly and positively impacted academic achievement. Moreover, in the study by Kim and Shin [87], definitive evidence was identified that self-efficacy directly influenced English language achievement. In viewing this, we think that it is justifiable to raise the hypothesis that self-efficacy plays an indirect mediational role in the relationship between teachers' perceived online learning quality assessed under the CoI framework and their learning achievement. Results from the present study confirmed this hypothesis.

Similarly, perceived online learning achievement was also reported as a significant mediator in the relationship between online professional learning quality assessment and teachers' sense of efficacy. In other words, teachers grow a higher level of self-efficacy in favorable professional learning communities due to their improved learning achievement perception.

The correlational relationship between learners' self-efficacy and learning achievement is widely acknowledged. As stated above, possessing a high level of self-efficacy should consequently witness enhanced learning performance. Hence, it is reasonable to predict that favorable learning performance should, in turn, enhance an individual's self-efficacy level. Past research bolstered this prediction. For instance, Pajares and Johnson [88] acknowledged that better-performing students receive more positive evaluations, which consequently witnessed higher self-efficacy levels and less apprehension. Similarly, Zimmerman and Kitsantas [89] stated that strong academic performance strengthens learners' self-efficacy by boosting confidence and encouraging students to actively engage in learning tasks, resulting in better academic performance. In light of the existing literature, it is also justifiable for the present research to propose teachers' online learning achievement as a mediating factor that explains the effect of perceived online learning quality assessed under the CoI framework on teachers' self-efficacy. Results from the present research supported our hypothesis.

Finally, we also inquired about the time our participants spent receiving online professional development courses and using online professional learning resources in the past 12 months. We suspected the disparate length of professional learning time might alter the effect between online professional learning quality assessment and perceived learning achievement. Moreover, we hypothesized that the moderating role of time should be positive, which signifies that the more time spent on online professional learning, the stronger the effect online learning quality should have on learning achievement. It is self-evident and supported that time spent on learning plays a positive role in learners' academic achievement (e.g. Refs. [90,91]). Conscientious learners often devote more time to studying. However, contrary to what we posited, a moderation analysis revealed that the time spent on online learning is a valid negative moderator for the model. Specifically, when teachers devote less time to online professional development, online learning quality

should have a stronger effect on learning achievement. We suspect that the reason behind this result is that prolonged and conscientious learning makes study time the primary factor affecting academic performance when compared with perceived learning quality. More specifically, when learners devote little time to study, the learning quality is vital to enhancing academic performance. On the other hand, when learners work diligently, the quality of their learning will have little impact on academic performance. More research is needed to further confirm and explore this phenomenon to offer a more comprehensive understanding of the mechanism behind it.

6.3. Implications, limitations, and future directions

The present research offers significant implications for addressing the academic lacuna and empirical guidance. No research in the realm of Community of Inquiry and teacher professional development has exploited the Community of Inquiry framework not as a guide to design courses but as an assessment of teachers' online professional learning quality. Moreover, situating the research in the Chinese middle school context is an academic lacuna and a desideratum. Finally, the present research is the first to comprehensively explore the relationship between the Community of Inquiry framework, teachers' self-efficacy, and their perceived professional learning achievement using linear regressions, mediation analyses, and moderation analysis. As for the empirical implication, it is self-evident that the quality of online professional learning for teachers bears immense influence on teachers' self-efficacy and learning achievement. Hence, it is imperative for institutes, associations, and online platforms to improve their online professional learning course designs and enrich the online learning resources. In such a way, teachers will experience a better quality of online professional development, resulting in fruitful online learning achievement and enhancing their teaching efficacy.

Nevertheless, improvements can still be made to the present research. First, the nature of the convenience sampling strategy is bound to the lack of generalization power. The participants were recruited from only several Chinese middle schools, resulting in the sample's lack of representativeness given the expanse of the country and a wide arrange of schools. Future research may select different sampling strategies to address this issue. Second, to measure teachers' online professional learning achievement, we adopted self-report to allow teachers to actively report their perceptions of learning achievement. This is not the best way to measure learning achievement. The self-reported fashion of measuring learning achievement often bears the influence of other confounding variables, such as participants' social desirability bias. Future research can develop a valid and reliable way to examine teachers' online professional learning achievement or use sophisticated tests when probing specific learning subjects. Third, the R^2 value of the regression analysis for the relationship between teachers' online learning quality and their sense of efficacy is small (the model explains only 10% of the variance). Hence, more latent variables for this relationship are waiting to be revealed. Future research can devote its attention to addressing this need. Moreover, the present study only explored Chinese middle school teachers' online professional learning. Expanding the target sample group to include primary school and university teachers would be meaningful. Finally, it is advised that future research exploit different methods for data collection other than distributing questionnaires to explore the proposed relationships.

7. Conclusion

Findings from this research supplement empirical evidence regarding the relationships between teachers' assessments of online professional learning quality, their sense of efficacy, and perceived online learning achievement. The results emphasized the significant predictive role of online professional learning quality in affecting teachers' self-efficacy and learning achievement, along with the mediating roles of self-efficacy and learning achievement and the moderating role of time spent in online learning in the model. These results are also significant in their pedagogical implications as they enlighten students to put a higher value on the quality of online learning instead of focusing on the learning materials and instructors. Besides, the results also encourage students to emphasize the consequence brought by self-efficacy and online learning time.

Author contribution statement

Mingzhe Wang: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Lawrence Jun Zhang: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

The data that support the findings of this study are openly available in "figshare" at <https://doi.org/10.17608/k6.auckland.21601620.v5>

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Consent to participate

Informed consent to participate was obtained from all individual participants included in the study.

Consent for publication

Informed consent for publication was obtained from all individual participants included in the study.

Declaration of competing interest

The authors have no interests to declare.

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