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The Development and Validation of an Instrument to Collaborative Teaching Assessment under the Impact of COVID-19 through the SECI Model

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Abstract: Information and communications technology (ICT) has bridged the gap between students and universities during the COVID-19 pandemic. As COVID-19 brings pandemic pedagogy to transnational higher education (TNHE), the emergent response of Chinese universities to this disruption to education has been to update practices to tackle the pedagogical and contextual differences in transnational education. However, few studies have examined the impact of the pandemic on TNHE through the lens of the socialization, externalization, combination and internalization (SECI) model and investigated the extent to which teaching faculty can co-construct knowledge in collaborative teaching with the assistance of ICT. This study uses the theoretical framework of the SECI model to explore whether collaborative teaching was effective in TNHE during COVID-19. A quantitative questionnaire is conducted to examine the joint knowledge production by adding information technology utilization to the four knowledge-creation and knowledge-conversion processes. Finally, the study explores a SECI knowledge-creation model with technology integration for discussing collaborative teaching quality during COVID-19. The results imply that collaborative teaching management can be linked to the multidimensions of knowledge generation and transfer. It also recommends that pedagogical knowledge and technological expertise can enhance instructional design and teaching practices from the knowledge perspective and achieve sustainable development in THNE.

Keywords: collaborative teaching; COVID-19 impact; SECI model; technology utilization; scale validation; transnational higher education

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1. Introduction

The major function of higher education institutions (HEIs) is to provide an organizational basis for research on all forms of knowledge [1]. Thus, knowledge creation and transmission are the primary aims of HEIs. The need to change at both the national and international levels drive HEIs to tackle more when confronted with deciding how to produce, manage and transit knowledge [2]. They also respond rapidly to the significant changes in information technology and the increasing demands of a knowledge-based society [3]. However, the COVID-19 pandemic acted as a natural breaching experiment, whereby normal pedagogies were suddenly disturbed, and the teaching faculty needed to adjust their instruction [4]. Educational institutions and their teachers, professors, and students are quickly moving from physical classrooms to online settings because of the global COVID-19 pandemic [5]. The impediments to successful transitions reflect the positive experiences of educational change during COVID-19. Curriculum and pedagogy innovations went forward to build on the positive aspects of practice, including collaborative teaching using information and communications technology (ICT) [6]. This shift brought historic opportunities for the teaching faculty to manage virtual exchanges and blended teaching. In transnational higher education (TNHE), collaborative teaching establishes professional connections to overcome isolation [7]. Mendoza applied the SECI knowledge conversion

model, developed by Nonaka (1995) [8], as an analytical tool to explain the creation and transfer of knowledge among collaborative teaching teams [9]. Owing to the increasing need for knowledge management (KM) in TNHE, growing research has been devoted to enhancing KM technologies [10], producing and sharing academic knowledge [11], mapping and measuring knowledge [12] and fostering learning and education [13].

However, the existing literature does not support virtual collaborations in TNHE. There has been limited research on TNHE during the COVID-19 pandemic. This lack has been worsened by the fact that there have been some attempts to provide insights into international students' experiences, but this review is limited only to students' anxiety about their studies and future careers [14]. However, such a big challenge to the physical mobility of TNHE and the expansion of virtual knowledge exchange during the COVID-19 pandemic has called for an in-depth investigation to trace what has been done and what will be done in the future, considering the unique forms of knowledge creation and conversion in the TNHE landscape.

This study assessed collaborative teaching from the perspective of the SECI model to understand KM maintains educational resource exchanges and teaching quality during the COVID-19 pandemic in Chinese universities. The starting point of this study was to develop a tool to monitor the quality of collaborative teaching under the impact of COVID-19. This research project seeks to address the following questions: (1) What is the reliability and validity of the SECI model in assessing collaborative teaching assisted by ICT in the COVID-19 setting? (2) How does the application of the SECI model contribute to the effectiveness of collaborative teaching in TNHE during the COVID-19 pandemic?

The remainder of this paper is organized as follows. In Section 2, we present the literature review, followed by the methodology and analytical framework of the study in Section 3. Section 4 discusses the main findings regarding the exploration and validation of the instrument. These findings link collaborative teaching assisted by ICT utilization to multiple dimensions of knowledge creation and transmission. Finally, Section 5 presents the conclusions and limitations of this study.

2. Literature Review

2.1. TNHE during the COVID-19 Pandemic

The COVID-19 pandemic has had an unprecedented impact on the landscape of TNHE from the physical mobility between and within countries owing to public health concerns [15], which is the most frequent cross-border mode of knowledge transfer in HE [16]. The policy differences between national systems during the COVID-19 pandemic are also a barrier to academic synergies from international collaborations [17]. This is because there is a risk that a partnership university could interpret such differences as an indication of reluctance to engage in exchange, cooperation and mobility [18]. Online learning platforms, remote laboratory simulations and online proctoring are repair strategies used for breaching normal classroom norms during COVID-19 [19]. Many TNHE institutions have developed or adopted online learning platforms that allow the teaching faculty to prepare course materials and conduct virtual classes from anywhere in the world [20]. These platforms often include features such as live video conferencing, discussion forums and interactive quizzes to help students engage with the course content. For academic subjects such as science and engineering, remote laboratory simulations have been developed to allow students to conduct experiments and practice skills without having to be physically present in a laboratory [21,22]. Therefore, the pandemic has driven educational institutions to carefully balance the use of information technology and TNHE quality assurance.

2.2. Collaborative Teaching Assisted with ICT

Collaborative teaching is a dynamic process, starting at the individual level and finally reaching out through interactions that surpass the individual, team and organizational ranges. The active interaction and leveraging strengths among academics encourage team members to share ideas and provide suggestions for improving teaching quality [23].

Collaboration in team teaching during COVID-19 requires more time and effort for teachers to work together on planning, teaching and assessment [24]. The introduction of ICT in education has increased access to quality education and technology-assisted teaching [25]. During the COVID-19 pandemic, teachers have been forced to utilize more technology in their teaching and form a more supportive technology environment. However, this technology requires the introduction of new technological and pedagogical knowledge into virtual classes [26]. It is important to consider students' learning needs in relation to the materials to be taught and the methods by which teachers are to instruct. Whether teachers can utilize technology to assist their teaching practice or to create a better knowledge transmission environment is influenced by their knowledge of technology [27].

Teachers acquire or increase their own digital proficiency, which ranges from mastering technical tools to developing new pedagogies, such as managing group work and assessments online [28]. This also causes profound changes in the teachers' work. These include teaching students who were separated from each other by distances that exceeded those in regular classes, trying to sustain cooperative learning activities in physically distanced environments and sustaining an emotionally supportive environment when physical contact and proximity were limited [29].

2.3. SECI Model Application in TNHE

TPACK is a theoretical framework of teachers' pedagogical content knowledge regarding the integration of technology into teaching [30]. This conceptual framework elaborates that teachers' pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK) are all essential for effective teaching and technology-enhanced teaching environment integration [31]. KM involves knowledge sharing, creation, validation and application [32]. It also emphasizes the integration of technologies [33]. The SECI model is a knowledge-creating process in a spiral form that goes in a cycle of four processes: socialization, externalization, combination and internalization (see Figure 1) [34].

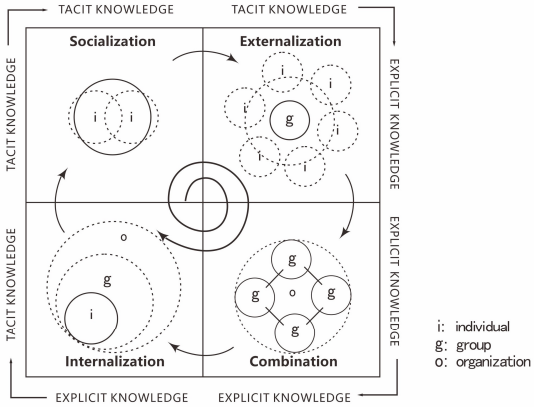

Figure 1. Spiral evolution of the SECI model.

In collaborative teaching in TNHE, these four processes are elaborated as follows:

Socialization is a knowledge conversion mode that converts tacit knowledge through interactions between individuals [8]. This mode of knowledge conversion involves the sharing of tacit knowledge through social interactions. In the context of TNHE, individual tacit knowledge in teaching experiences and practices can be shared with and absorbed by other team members. This could involve faculty members or students from different countries sharing their experiences and perspectives during in-person or online discussions [9].

The externalization mode captures tacit knowledge and expands it into explicit knowledge through mutual interaction [8]. This mode of knowledge conversion involves articulating tacit knowledge into explicit knowledge. In the context of collaborative teaching in TNHE, this could involve faculty members documenting their teaching experiences and in-

structions, which can be shared with others in a virtual scenario. This happens when tutors' tacit pedagogical thinking and actions are converted into explicit pedagogical knowledge expressed in teaching beliefs, methodologies or academic knowledge during collaborative class preparation activities [35]. Pedagogical idea exchanges during the unprecedented COVID-19 pandemic may be ambiguous or vague; however, they can be made clearer through verbal or image communication.

Combination involves the use of social processes to combine different bodies of explicit knowledge held by individuals [8]. This mode of knowledge conversion involves the integration of different types of explicit knowledge and the creation of new explicit knowledge. Collaborative teaching scenarios involve collaboration between faculty members from different institutions to develop joint research projects or courses that draw on their respective areas of expertise [9]. Faculty members within a teaching team exchange their explicit knowledge of teaching materials, curriculum outlines and assessment strategies through virtual mechanisms, such as online class preparation meetings, assessment standardization videoconferences and email communication. Tutors create new academic knowledge by sorting, adding and prizing existing knowledge from teaching and assessment materials.

Internalization is a conversion mode that transforms organizational knowledge into tacit knowledge [8]. This mode of knowledge conversion involves individuals internalizing explicit knowledge and developing tacit knowledge. In the collaborative teaching scenario, internalization refers to incorporating knowledge into teaching to achieve better learning results from students, involving faculty members applying the knowledge gained from collaborations with colleagues in different countries to their own teaching and research practices [9].

2.4. Ba in TNHE

Ba refers to the shared context of the space in which knowledge is created and shared among students, faculty and other stakeholders across geographic locations [36]. Ba is the core concept of the SECI knowledge-creation model.

During the COVID-19 pandemic, ba can be understood as the physical and virtual environment in which learning and teaching occur. Ba includes not only physical spaces, such as classrooms, laboratories, libraries and other learning facilities, but also virtual spaces, such as online platforms, discussion forums and social media. Cyber ba, created from the ICT scenario, refers to the shared virtual space or context in which knowledge is created and shared among students, faculty, and communication technologies. As universities and colleges increasingly offer programs and courses across borders, cyber ba has become an important element of the SECI model for knowledge creation in TNHE [37]. It allows learners and educators to collaborate and exchange ideas, regardless of their physical location, through various online platforms and tools, such as learning management systems, virtual classrooms, discussion forums and social media. The effective use of cyber ba in TNHE can enhance the quality of learning and teaching, promote intercultural exchange and foster a sense of community among learners and educators [38]. However, it also presents challenges, such as technological barriers, cultural differences and language barriers, that must be addressed to ensure the success of TNHE initiatives.

3. Research Methodology

3.1. Participants

This investigation takes place in the context of the TNHE in China during COVID-19, which focuses on analyzing collaborative teaching with technology utilization. To address the research questions, we used a convenience sampling method. Participants were randomly selected from eight joint programs in China: Southampton International College in Dalian Polytechnic University which started from 2012, UCI in Dalian University of Technology which started from 2018, IFCM in University of International Business and Economics which started from 2010, TDU in Beijing University of Technology which started from 2002, Beijing University of Posts and Telecommunications–Queen Mary University of

London joint degree program which started from 2003, Shanghai Jiao Tong University SJTU-UM Joint Institute which started from 2001, Shanghai University of Finance and Economics and University of Central Lancashire joint program which started from 2004, Missouri Institute in Xiamen University of Technology which started from 2017 and the Institute of Creativity and Innovation in Xiamen University which started from 2020. This form of cooperative program in HE enables students to access both foreign and China's excellent education through different modes of teaching and learning. All the joint programs in this study are approved by Ministry of Education of the People's Republic of China and details can be found on the website of Chinese–Foreign Cooperation in Running Schools. The participants received an invitation by email and consented to participate in the survey. A total of 450 questionnaires were collected, and 10 were identified as invalid answers because they left some questions unanswered or gave random responses. Thus 10 invalid responses were excluded, and 440 participants were included in this study. The demographic data of the participants is shown in Table 1.

Table 1. Demographic profile.

Items	Categories	Number	Percentage (%)	Cumulative Percentage (%)
Age	21–30	27	6.14	6.14
	31–40	282	64.09	70.23
	41–50	109	24.77	95
	51–60	22	5	100
Gender	female	295	67.05	67.05
	male	145	32.95	100
Years in TNHE	1–5	105	23.86	23.86
	5–10	251	57.05	80.91
	10–15	75	17.05	97.95
	15–20	9	2.05	100
Highest education	Bachelor's degree	22	5	5
	Master's degree	273	62.05	67.05
	PhD degree	145	32.95	100
Nationality	Canadian	53	12.05	12.05
	Chinese	146	33.18	45.23
	French	20	4.55	49.77
	Germany	22	5	54.77
	Irish	8	1.82	56.59
	Israeli	9	2.05	58.64
	Malaysian	4	0.91	59.55
	Russian	40	9.09	68.64
	Singaporean	13	2.95	71.59
	British	89	20.23	91.82
	American	36	8.18	100
Total		440	100	100

3.2. Questionnaire Design

The items were designed to measure how the SECI model has been applied in the context of TNHE collaborative teaching during COVID-19, with a focus on how digital tools and information platforms have facilitated knowledge creation and transfer among teaching faculty. The questionnaire was developed from the literature on knowledge conversion in the SECI model [9]. Owing to the lack of physical mobility of tutors and students during COVID-19, hybrid teaching modes are very common in TNHE. Technological utilization plays an important role in collaborative teaching. Thus, the items were adapted for information technology utilization, supplemented by Schmid's research [39]. The final 23 items of the questionnaire included statements assessing the SECI processes, knowledge transfer and technological pedagogical content knowledge during the COVID-19 pandemic.

Inclusion of additional scale options results in an increased statistical correlation and the six-point scale method contributes further to the systematic variance [40]. Thus, participants rated their level of agreement on a six-point Likert scale, from 1, which represents totally disagree, to 6, which means to totally agree.

3.3. Data Analysis

The sample (n = 440) was randomly divided equally into two groups: 220 participants for an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA). To identify the four factors influencing the variables and analyze which variables are correlated, this study first used an EFA, assembling common variables into descriptive data on collaborative teaching. Then, CFA is conducted to test and confirm the hypothesized factor structure. EFA and CFA were conducted by using R language.

4. Results and Discussion

4.1. Exploratory Factor Analysis

The randomly selected half of the sample (n = 220) showed a remarkable KMO value (0.9) in Table 2, which is over 0.6, and Bartlett's test $p < 0.05$, indicating that the sample is sufficient [41].

Table 2. KMO and Bartlett test.

Test		Results
KMO		0.9
Bartlett test	Approx. chi-square	3829.22
	df	253
	p value	<0.001

Table 3 presents the factor extraction based on the results of the factor analysis. Four factors with eigenvalues greater than 1 were extracted [42]. The variances explained by the four rotated factors are 20%, 18%, 16% and 15%, respectively. The sum of the variances explained by all the factors or components extracted from the data is 70%.

Table 3. Total Variance Explained.

	Factor 1	Factor 2	Factor 3	Factor 4
SS loadings	4.57	3.77	3.55	4.12
Proportion Var	0.20	0.16	0.15	0.18
Cumulative Var	0.20	0.36	0.51	0.70
Proportion Explained	0.29	0.24	0.22	0.26
Cumulative Proportion	0.29	0.53	0.75	1

The maximum variance method (varimax) was used to rotate the data to identify the corresponding relationship between the factors and the research items. Table 4 shows the extracted values of the factors for the research items and the corresponding relationships between the factors and the research items. As shown in Table 4, the absolute values of the factor loading cutoff for all research items are greater than 0.6, indicating a strong correlation between the research items and the factors and that the factors can effectively extract information [42]. The data results in EFA indicate that development of new measurement scales from the SECI model have internal consistency. The instrument identifies collaborative teaching assessment regarding ICT assistance during COVID-19.

Table 4. Exploratory factor analysis of 23 items.

Items	Mean	SD	Factor 1	Factor 2	Factor 3	Factor 4
1. I often listen to and apply other team members' opinions in teaching content, teaching skills and assessment criteria from weekly online preparation meeting and daily email exchanges.	4.177	1.421	0.17	0.08	0.1	**0.82**
2. I can share my teaching experiences and generalize a set of teaching beliefs, sharing with team members through cyber ba.	4.259	1.375	0.15	0.06	0.17	**0.77**
3. I will compare the newly appeared teaching methods, which were created from the hybrid mode with my existed experience, to have a deep understanding of pedagogy transformation in the COVID-19 pandemic.	4.123	1.381	0.11	0.06	0.08	**0.85**
4. I dare to ask when I have questions, when I disagree or have ambiguity with others' ideas on material designing, teaching methods and course design delivering through Blackboard, Zoom and emails.	4.173	1.48	0.14	0.06	0.16	**0.82**
5. I often participate in online forums and discussions groups with other collaborative members to share knowledge and ideas during the COVID-19 pandemic.	4.295	1.42	0.18	0.07	0.1	**0.75**
6. I often try to exchange difficulties I have met with others during collaborative preparation meeting.	4.164	1.43	0.11	0.05	0.16	**0.81**
7. I can reach agreement with other members in the course outline of collaborative teaching during the COVID-19 pandemic.	4.264	1.406	**0.82**	0.04	0.08	0.13
8. The whole teaching team can prepare course materials effectively and collaboratively during weekly collaborative preparation cyber-meeting.	4.295	1.443	**0.77**	0.01	0.04	0.14
9. Members of the collaborative teaching team can share their teaching materials weekly in pursuit of professionals and academic knowledge.	4.232	1.442	**0.81**	−0.02	0.01	0.15
10. Most of the team members hold a positive view towards new pedagogies in the COVID-19 pandemic.	4.295	1.371	**0.82**	−0.01	0.02	0.16
11. When an instructor from the collaborative teaching teams has questions and consults with other team members, they will endeavor to answer the questions, no matter if in China or outside China.	4.336	1.373	**0.78**	−0.05	0.06	0.06
12. When members discuss the academic knowledge input, they will attempt to provide their own opinions during the online class preparation meeting or email exchanges.	4.268	1.406	**0.76**	−0.03	0.17	0.12
13. Most team members can express their opinions about course design and teaching plan very clearly and understandably in cyber ba.	4.373	1.374	**0.79**	0.01	0.11	0.15
14. I have a deep cognition of the teaching aims and assessment criteria of academic subjects through class preparation and standardization meeting through online meetings.	4.173	1.445	0.1	0	**0.81**	0.14
15. Collaborative teaching team members develop better teaching skills catering to the COVID-19 pandemic period through online preparation meetings.	4.136	1.414	0.09	0.01	**0.82**	0.12
16. Collaborative teaching team members can closely relate. They can also adopt the hybrid teaching knowledge and hybrid teaching experience through class preparation meeting and email communication.	4.277	1.331	0.1	−0.01	**0.83**	0.15
17. The class implementation after collaborative meeting and team member communication can support me in internalizing other members' teaching knowledge into my own knowledge.	4.191	1.477	0.05	0	**0.82**	0.17
18. Collaborative class preparation helps me to integrate my own knowing and experience to collaborative teaching team, which will finally improve the hybrid teaching quality of the team.	4.132	1.302	0.05	0.04	**0.82**	0.11
19. When instructors from the collaborative teaching team fail to get others point of view, I can often successfully explain with proof and information among teams' members.	4.218	1.323	0.01	**0.83**	−0.07	0.14
20. I can convert curriculum theories into understandable verbal descriptions to assist the delivery among team members in the aspect of course design, course management and assessment criteria.	4.186	1.347	0	**0.88**	0.02	0.01
21. I can organize my hybrid model and share my teaching reflections and teaching beliefs with others.	4.077	1.274	−0.04	**0.87**	−0.03	0.08
22. E-learning platforms or online courses have helped me deepen my knowledge and skills related to TNHE collaborative teaching during the COVID-19 pandemic.	4.214	1.301	0.01	**0.87**	0.04	0.09
23. Personal information management tools have helped me organize and manage my TNHE teaching knowledge during the COVID-19 pandemic.	4.164	1.375	−0.03	**0.87**	0.08	0.04

Bold values represent factor loadings greater than 0.6.

4.2. Confirmatory Factor Analysis

The other half of the sample tested the four-factor model for CFA using the 23-item questionnaire identified in the EFA. The four-factor model showed a good goodness-of-fit.

The absolute values of the standardized loading coefficient in Figure 2 and Table 5 are greater than 0.6 and are significant, indicating a strong relationship [43]. As can be seen in Table 5, the AVE values for all four corresponding factors are greater than 0.5, and the CR values for all factors are higher than 0.7, indicating that the analyzed data have good convergent validity [44,45].

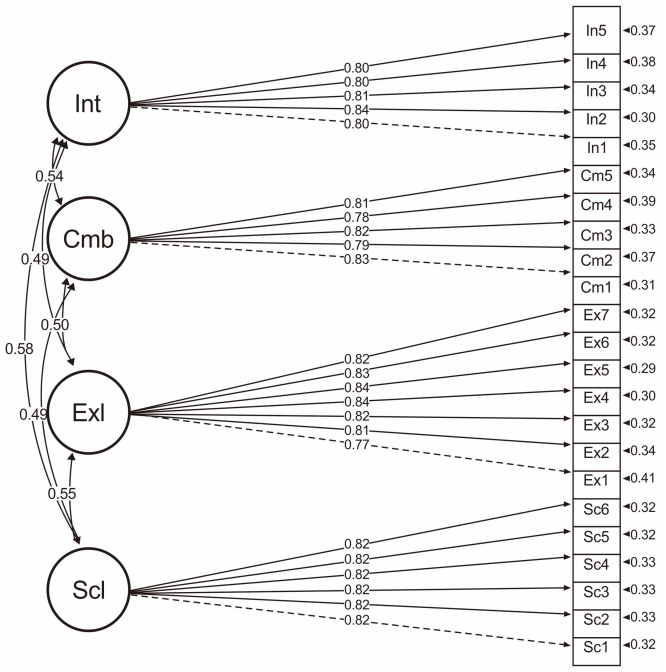

Figure 2. Four factor structure and standard factor loadings.

Table 5. Results of convergent validity tests of the full model.

Items	Estimate	S.E.	C.R.	P	Std. Estimate	AVE	CR	Cronbach α
1. I often listen to and apply other team members' opinions in teaching content, teaching skills and assessment criteria from weekly online preparation meeting and daily email exchanges.	1		14.347		0.824	0.674	0.925	0.934
2. I can share my teaching experiences and generalize a set of teaching beliefs, sharing with team members through cyber ba.	1.033	0.072	14.256	*** [1]	0.819			
3. I will compare the newly appeared teaching methods, which were created from the hybrid mode with my existed experience, to have a deep understanding of pedagogy transformation in the COVID-19 pandemic.	0.994	0.07	14.31	*** [1]	0.816			
4. I dare to ask when I have questions, when I disagree or have ambiguity with others' ideas on material designing, teaching methods and course design delivering through Blackboard, Zoom and emails.	0.965	0.067	14.491	*** [1]	0.818			
5. I often participate in online forums and discussions groups with other collaborative members to share knowledge and ideas during the COVID-19 pandemic.	0.994	0.069	14.49	*** [1]	0.825			
6. I often try to exchange difficulties I have met with others during collaborative preparation meeting.	1.006	0.069		*** [1]	0.825			
7. I can reach agreement with other members in the course outline of collaborative teaching during the COVID-19 pandemic.	1		12.963		0.768	0.673	0.935	0.932

Table 5. *Cont.*

Items	Estimate	S.E.	C.R.	P	Std. Estimate	AVE	CR	Cronbach α
8. The whole teaching team can prepare course materials effectively and collaboratively during weekly collaborative preparation cyber-meeting.	1.03	0.079	13.177	*** [1]	0.813			
9. Members of the collaborative teaching team can share their teaching materials weekly in pursuit of professionals and academic knowledge.	1.099	0.083	13.451	*** [1]	0.824			
10. Most of the team members hold a positive view towards new pedagogies in the COVID-19 pandemic.	1.146	0.085	13.499	*** [1]	0.838			
11. When an instructor from the collaborative teaching teams has questions and consults with other team members, they will endeavor to answer the questions, no matter if in China or outside China.	1.165	0.086	13.234	*** [1]	0.841			
12. When members discuss the academic knowledge input, they will attempt to provide their own opinions during the online class preparation meeting or email exchanges.	1.054	0.08	13.161	*** [1]	0.827			
13. Most team members can express their opinions about course design and teaching plan very clearly and understandably in cyber ba.	1.107	0.084		*** [1]	0.824			
14. I have a deep cognition of the teaching aims and assessment criteria of academic subjects through class preparation and standardization meeting through online meetings.	1		13.521		0.832	0.655	0.904	0.923
15. Collaborative teaching team members develop better teaching skills catering to the COVID-19 pandemic period through online preparation meetings.	0.893	0.066	14.178	*** [1]	0.792			
16. Collaborative teaching team members can closely relate. They can also adopt the hybrid teaching knowledge and hybrid teaching experience through class preparation meeting and email communication.	1.002	0.071	13.271	*** [1]	0.819			
17. The class implementation after collaborative meeting and team member communication can support me in internalizing other members' teaching knowledge into my own knowledge.	0.856	0.065	14.021	*** [1]	0.782			
18. Collaborative class preparation helps me to integrate my own knowing and experience to collaborative teaching team, which will finally improve the hybrid teaching quality of the team.	0.924	0.066		*** [1]	0.813			
19. When instructors from the collaborative teaching team fail to get others point of view, I can often successfully explain with proof and information among teams' members.	1		13.984		0.804	0.657	0.905	0.927
20. I can convert curriculum theories into understandable verbal descriptions to assist the delivery among team members in the aspect of course design, course management and assessment criteria.	1.081	0.077	13.362	*** [1]	0.839			
21. I can organize my hybrid model and share my teaching reflections and teaching beliefs with others.	1.012	0.076	13.191	*** [1]	0.810			
22. E-learning platforms or online courses have helped me deepen my knowledge and skills related to TNHE collaborative teaching during COVID-19 pandemic.	0.993	0.075	13.036	*** [1]	0.802			
23. Personal information management tools have helped me organize and manage my TNHE teaching knowledge during the COVID-19 pandemic.	0.963	0.074	14.347	*** [1]	0.795			

[1] ***: $p < 0.001$.

According to the model fit indices from the CFA (Table 6), the $\chi 2/df$ ratio is less than 3, and the RMSEA is less than 0.10. Further, CFI = 0.990, TLI = 0.988 (a value of above 0.90 is typically considered to indicate an acceptable fit), RMSEA = 0.028 (values less than 0.05 indicate a good fit) and SRMR = 0.041 (values less than 0.08 indicate a good fit) [46]. Overall, based on the comprehensive evaluation of this CFA model, the data fit well according to the goodness-of-fit indices, and the factor loadings strongly supported the hypothesized relationships between the SECI model's four factors and their indicators.

Table 6. Item fit indices.

χ2/df	GFI	AGFI	RMSEA	RMR	CFI	NFI	TLI	IFI	SRMR
1.162	0.906	0.884	0.028	0.058	0.990	0.932	0.988	0.990	0.041

4.3. Discussion

4.3.1. The Four-Factor Instrument

This study aimed to fill the research gap in KM within collaborative teaching in TNHE during the COVID-19 pandemic from an academic knowledge perspective. It applies the SECI model to TNHE research and validates an instrument for assessing collaborative teaching assisted by technology utilization. The results identify four factors of assessing collaborative teaching from the SECI model: socialization, externalization, combination and internalization. The KM processes were found to significantly influence tutors' collaborative teaching quality during the COVID-19 pandemic.

The knowledge socialization factor measures how the collaborative teaching team share their tacit knowledge and teaching experiences in cyber ba. Teaching faculty can exchange their experiences and practices, indicating that they can explain their tacit knowledge to others with the assistance of ICT. During the COVID-19 pandemic, many creative pedagogies and practices for teaching material design and knowledge delivery have been employed. The teaching faculty must accept the original methods of teaching tacit knowledge. In addition, they need to upgrade their pedagogies and teaching beliefs by teaching knowledge exchange to reduce students' study difficulties from a lack of physical mobility. This result indicates that socialization in collaborative teaching can help faculty members prepare curriculum pedagogies and teaching materials well through tacit knowledge exchange. This also echoes Lim's finding that the effectiveness of collaborative teaching is affected by colleagues' teaching beliefs and practices in the team [23]. Instructors who have stronger inclination towards collaborative teaching pedagogical beliefs were found to be more dedicated in integrating technology into their teaching practices, which consequently led to improvements in their technology-related design skills.

The knowledge externalization dimension measures how faculty members transform the pedagogical beliefs into perspectives for sharing and interpreting texts, words or concepts. Faculty members can codify the existing teaching resources and improve other members' understanding of how to apply academic knowledge to their classes. The effective integration of technology into teaching involves more than simply introducing educational technologies into the classroom; it requires consideration of the perspectives and ideas of all stakeholders regarding the subject matter to be taught and the pedagogical approaches to be implemented by faculty members. The systematic integration of technology into collaborative teaching practices, as well as the use of technology to enhance cyber ba, is contingent on the teaching faculty's beliefs and attitudes toward the role of technology in pedagogy [47]. Faculty members reflect on their teaching materials and curriculum pedagogies explicitly through class-preparation videoconferences and discussion forums. This sharing of preliminary ideas with team members helps improve the faculty members' knowledge recodification in the academic knowledge transfer process. This finding validates Guzman's study, emphasizing the diverse nature of knowledge and the knowledge transfer process to fit special needs [48].

The knowledge combination dimension weighs how the participants organize and generalize their collective teaching experiences, which are vague, to share with others. Readiness of individuals is related to their organizational vision. A clear organizational perception of online teaching, together with a clear individual perception can create an overall vision of readiness for pedagogical technology utilization [49]. During preparation for videoconferences and discussion forums, they listen to other faculty members' opinions and observe their reflections on the changes in teaching materials and pedagogies. The teaching faculty also share different viewpoints with the team members to tackle the newly emerging difficulties caused by the pandemic. The successful integration of technology into teaching practices necessitates a significant investment of time and effort and is contingent upon an appropriate group instructional design framework [50]. Thus, faculty members are encouraged to use technology in their teaching and to create a more technology-facilitated cyber ba for collaborative teaching [51]. Technology utilization in curriculum design and pedagogical practices also has several challenges and obstacles. However, an open attitude can pave the way for academic knowledge transfer and eliminate the impedance of the pandemic. This validates Edu's findings that team members' instructional practices influence the effectiveness of collaborative teaching [52].

The knowledge internalization process weighs the extent to which tutors can internalize and apply the collectively prepared teaching materials to individual teaching practices and how they can adopt them to facilitate knowledge sharing through learning-by-doing [53]. Course outlines, assessment criteria and teaching materials are easily shared within a learning management system. Through discussion forums and class-preparation videoconferences, it is sometimes difficult to teach art. Moving the teaching staff to educational receivers is one of the main ways to share tacit academic knowledge. Although the pandemic has blocked the physical mobility of teaching staff, network movement is supported by the utilization of information technology. The faculty members teaching knowledge influences their attitudes toward technology utilization in curricular design and pedagogical practices. Personal systematic changes in the communication among faculty members is required to ensure that they gradually integrate technological and pedagogical knowledge to support collaborative teaching practices.

4.3.2. Effective Collaborative Teaching in TNHE during the COVID-19 Pandemic from Knowledge Perspective

The instrumental development and invalidation reveal that partners engaged in TNHE are able to acquire and transfer teaching knowledge through ICT assisted collaboration during the COVID-19 pandemic. Partnerships are willing to share and create academic knowledge by collaboratively developing course outlines, teaching materials and assessment criteria in explicit knowledge. For tacit knowledge conversion, the teaching style of learning-by-doing has already been greatly impacted by the immobility of tutors and students. The teaching faculty strive to collaborate with others through idea exchange and collaborative class preparation in cyber ba. The more codifiable and transferable the knowledge they share through technology utilization during these processes, the more likely their knowledge will be shared and learned. This also corroborates previous findings that teachers can transform a virtual class into a systematic knowledge-creating unit [38]. Thus, compared to the other two processes, socialization, and internalization are more interactive and fruitful for tutors. Due to the inconveniences caused by the pandemic, the teaching faculty are reluctant or find it difficult to share tacit knowledge. This is because tacit knowledge can only be displayed face to face. In addition, sharing tacit knowledge requires a common sociocultural scenario. Although information technology utilization aims to eliminate immobility difficulties and achieve information flow, tacit knowledge is still more difficult to share and transfer during the COVID-19 pandemic, especially in practice courses [54]. Cooperation and collaboration in higher education are negatively affected by the lack of physical mobility. Technological content knowledge is essential for the faculty members to use technology effectively in collaborative teaching, which is en-

hanced by technology integration in cyber ba. This also verifies the conceptual framework of TPACK [30]. The TPACK framework concludes that the integration of technological content knowledge into pedagogical knowledge can help educators prepare better to tackle pedagogical challenges and teach technological inventions.

Explicit knowledge shared among faculty members during the COVID-19 pandemic includes slides, notes, outlines, online teaching materials and assessment criteria. Tutors also communicate online regarding their teaching experiences through weekly video meetings or email exchanges. However, online academic knowledge sharing is also inconvenient during the pandemic. Because of the Great Wall on the Internet, Chinese universities use different teaching software and conference tools from their outside partners. The differences in ICT's support also raise the protection of knowledge as a problem on both sides [55]. Not only do the courses delivered by both sides resemble the features of the partners, but there is also a different acknowledgement of the importance of tacit academic knowledge to facilitate explicit academic knowledge. This means that socialization, internalization, externalization or combination cannot guarantee that the local teaching faculty interpret knowledge the same way as they tend to deliver. This is particularly common in courses with a high degree of taciturnity. In this case, explicit knowledge is difficult to share without tacit understanding, which means that knowledge processes have difficulty reaching a spiral process. This is because perspectives on the same academic knowledge may be interpreted differently by tutors in China and around the world.

5. Conclusions and Limitations

The results of this empirical research interpret the four processes of the SECI model to enhance knowledge transfer and conversion in the context of ICT-assisted collaborative teaching. As a theoretical and analytical tool, the SECI model provides a new perspective on TNHE research during the COVID-19 pandemic. This indicates that collaborative teaching can promote knowledge transfer and conversion, although the pandemic has impeded the physical mobility of students and tutors. The findings also highlight the implications for both KM and collaborative teaching quality in TNHE in a hybrid teaching mode. Tacit knowledge in university courses is difficult to codify. However, with a positive attitude and the effectiveness of collaborative teaching and information technology utilization, both tacit and explicit knowledge can be captured in higher education partnerships.

The changes in teachers' work during COVID-19 have not only led to losses and gains during the pandemic, but many educators also expect more flexibility, adaptability and resilience in the face of unexpected disruption and challenges to the traditional modes of teaching [56]. Some of these changes continue within TNHE in some form or other once the pandemic is over.

Despite the findings of instrument exploration and validation, this study has some limitations. First, the participants were randomly selected from transnational HEIs in China, which may not be representative of samples from other areas. Further, this study built the instrument from an academic knowledge perspective. Future research can also explore a four-factor instrument from an organizational knowledge perspective and how to facilitate collective knowledge enhancement instead of individual knowledge improvement. Another limitation of this study was the paucity of technology integration into collaborative teaching. Technology utilization in collaborative teaching involves more than just providing tools. More research is needed to examine a powerful technological integration environment, that is, state-of-the-art cyber ba.

Overall, the COVID-19 pandemic has spurred a wave of innovation in TNHE, as HEIs have had to quickly adapt to new ways of delivering educational contexts and engaging with students. TNHE's response to the pandemic is not only aimed at addressing immediate challenges but also at creating a more sustainable and democratic future for higher education. A technology-based society has the capacity to improve the quality of education amid the challenges posed by the COVID-19 pandemic. Collaborative partnerships in TNHE play a crucial role in achieving the United Nations Sustainable Development Goals,

particularly in the areas of quality education and sustainable development [57]. These innovations seek to transform the higher education landscape in a way that is responsive, equitable and better equipped to face future crises.

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