



Assessing teachers' collaborative lesson planning practices: Instrument development and validation using the SECI knowledge-creation model

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ABSTRACT

Collaborative lesson planning (CLP) is a key component of teachers' professional development that responds to students' ever-increasing learning needs. This study aimed to develop and validate an instrument to evaluate teachers' CLP practices. Guided by the SECI (socialisation, externalisation, combination, and internalisation) knowledge-creation model of Nonaka and Takeuchi (1995), items assessing CLP practices were developed. To validate the CLP scale, we analysed data from 540 primary and secondary school teachers in Hong Kong. Exploratory factor analysis on a random half of the sample suggests a four-factor solution that supports the SECI model. A confirmatory factor analysis and multidimensional Rasch analysis on the remaining half of the sample confirmed the four-factor structure. Both analyses support the dimensionality of the four-factor model, rating scale effectiveness, and item fit statistics. The final version of the CLPS has 21 items that assess teachers' CLP practices under the four SECI processes. This instrument has practical value in assessing, monitoring, and promoting collaborative teaching practices in school. The study's limitations and implications are discussed.

1. Introduction

Education policy worldwide is constantly updated to maintain the sustainable development of schools and foster the learning capabilities of students. In China, education is shifting from an emphasis on a knowledge-based approach to a competency-based approach, in which schools need to nurture the Learning to Learn (LtoL) and self-regulated learning competencies of students (Shi & Cheng, 2020). In Singapore, the 21st-century skill curriculum has been implemented across specific subjects, schools, programmes, and systems (Tan, Monterola, Koh, & Ho, 2017). In Europe, curriculum reforms favour a competencies-based model to create a knowledge economy and demand greater pedagogical literacy and attention to teacher professional development (Leat, Thomas, & Reid, 2012). In Finland, a framework is used to develop students' Learning to Learn skills across the curriculum (Vainikainen, Hautamäki, Hotulainen, & Kupiainen, 2015). Personal learning and thinking skills are a key part of curriculum reforms in England (Mannion & Mercer, 2016). In Hong Kong, the Education Bureau has updated the curriculum to "Learning to learn 2.0+", which marks a new phase of curriculum renewal. Schools should prepare students for facing local and global changes and support their learning to learn (LtoL) and life-long learning.

As in other countries and areas, the implementation of the LtoL 2.0+ curriculum in Hong Kong (Curriculum Development Council, 2015; Curriculum Development Council, 2017; Curriculum Development Council, 2001) has created an urgent need to enhance the curriculum management capacity of Hong Kong schools (Cheng & Chan, 2021). It has impacted and created challenges for curriculum implementation and lesson design at various levels. The 'ongoing renewal of school curriculum' aims to enhance the self-regulated learning capabilities of students to promote effective life-long learning. The elements involved in this 'ongoing renewal of school curriculum' include a wide range of cross-curricular activities to develop students' self-regulated learning competencies. Schools are urged to implement these elements within, across, and sometimes beyond existing subject curricula.

Furthermore, the success of such reform relies on building a mechanism in schools to develop professional competencies among teachers from different subjects for implementing the curriculum effectively (Cheng, 2017, 2018). Collaborative lesson planning (CLP) is crucial to institutionalising competent experience-based teaching and curriculum management within schools. A mechanism for cross-subject collaborative lesson planning should be established to enable teachers to serve as knowledgeable others to share, alter and improve teaching strategies for the effective implementation of LtoL (Nyoni, 2018). However, the

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existing approaches to teacher collaborative lesson planning, including school-based action research, professional learning community and Lesson Study, do not provide a mechanism to explain how the pedagogical knowledge can be shared, developed and adopted by the teachers systematically.

Cheng (2018) applied the SECI knowledge conversation model developed by Nonaka and Takeuchi (1995) as an analytic lens to explain how Lesson Study could enable teachers to share, develop and adopt pedagogies for curriculum management. Given the importance of CLP for teachers and schools, this study aimed to develop and validate an instrument using the SECI model as the guiding framework to measure collaborative lesson planning among primary and secondary school teachers. In this article, we begin by formulating a theoretical definition of the CLP within the framework of the SECI model. We then report the development of the CLPS and examine its reliability and validity. Using data from focus group interviews combined with theoretical underpinnings of CLP, we have developed items that can capture teachers' CLP practices. We then used data collected from a total of 540 primary and secondary school teachers from 11 schools in Hong Kong SAR, China, to conduct exploratory and confirmatory factor analyses in examining the instrument's factor structure and apply a complementary Rasch analysis to test the dimensionality of the subscales and item fit. We end with discussions on the results of CLPS measurements among our sample group and their implications for practitioners and researchers.

1.1. Collaborative lesson planning (CLP)

Educational research has emphasised the need for collaborative learning structures to better enable teachers to respond to the increasing learning needs of students (Chong & Kong, 2012). Therefore, collaborative lesson planning (CLP) is a key component of teachers' professional development (Gutiérrez, 2019). Studies show that CLP is associated with subject-specific teaching efficacy (Bauml, 2014; Chong & Kong, 2012), improved instructional practices of teachers (Gutiérrez, 2021; Vescio, Ross, & Adams, 2008), and can even improve student achievement (Levine & Marcus, 2010; Reeves, Pun, & Chung, 2017). Rooted in a community of practice (Wenger, 1998), CLP fosters an environment where teachers can regularly interact and exchange ideas or insights for effective pedagogical practice (Gutiérrez, 2021; Wenger, 1998). This has made CLP a key ingredient for sustainable professional development for teachers within schools (Cochran-Smith & Lytle, 1992; 2009). Accordingly, the advantages of CLP have increased its implementation in schools (see Vescio, Ross, & Adams, 2008). However, despite CLP's known advances and advantages, there is little understanding of how CLP enhances teachers' pedagogical knowledge. There also remains no existing instrument that can evaluate teachers' CLP in schools. Such a research gap has made the monitoring, evaluation, and improvement of CLP in schools challenging.

1.2. Teachers' CLP practices

Collaborative lesson planning includes teachers' regular reflection on their instructional practices, goal setting, and pedagogical framing to aid effective lesson delivery (Eaker, DuFour, & Burnette, 2002). These practices embedded within CLP allow teachers to gain perspectives from their co-teachers that they can also implement in their own teaching (Williams, 2010). A recent framework by Gutiérrez (2021) effectively illustrates how CLP practices operate in a cyclical framework that includes (a) organising and reflecting on prior knowledge, (b) reflecting, organising, and developing new knowledge, (c) refinement and enactment, and (d) planning for task accomplishment. These practices then cycle back to the collaborative discussion, goal setting, and lesson implementation. The evidence suggests that as a result, CLP improves students' academic performance (Levine & Marcus, 2010; Reeves et al., 2017).

In evaluating CLP practices, previous studies have relied heavily on teacher interviews (see Gutiérrez, 2021) or on brief instruments in international surveys (e.g., for a 5-item collaborative teaching from the Trends in International Mathematics and Science Study [TIMSS] survey, see Reeves et al., 2017). Although both are useful for specific research purposes, such approaches could be biased and perhaps sub-optimal to validate instruments psychometrically. To the best of our knowledge, no one has developed an instrument to evaluate teachers' use of CLP. Furthermore, previous studies have not applied knowledge creation models that could further guide CLP implementation.

In response to this research gap, this study focused on developing and validating an instrument to evaluate teachers' participation in collaborative lesson planning for improving pedagogies. In the absence of a macro-theory that can comprehensively capture the underlying mechanisms of effective teacher collaboration (see Kelchtermans, 2006; Lavie, 2006), we used Nonaka's SECI (socialisation, externalisation, combination, and internalisation) knowledge creation model (Nonaka & Takeuchi, 1995) as a guiding framework for the instruments' development. The advantage that the SECI knowledge creation model provides to CLP is that it explains the codification of teachers' tacit knowledge (i.e., knowledge that is mostly acquired through direct experience or informal communication; see Polanyi, 1966) into subject-level or school-level explicit knowledge (i.e., articulated knowledge often through formal communication; see Cheng, 2014). In addition, the SECI model also articulates teachers' internalisation of the explicit knowledge into individual tacit knowledge through their teaching practices. Hence, the SECI model offers an ideal and applicable framework to house CLP in that teachers as individuals collaborate and share their knowledge to the group to build a *living* pedagogical repository that fellow teachers can contribute to, learn from, and practice. Below, we describe the SECI knowledge creation model and its four processes to emphasise how each can provide a structure to guide the development of an instrument to measure teachers' CLP.

1.3. CLP through Nonaka's SECI knowledge creation model

Given that CLP involves sharing teaching experiences and contemporary strategies for learning and instruction from an individual to a group and vice-versa, it is important to situate such knowledge-building practice within a theoretical knowledge-based model. The most influential and widely referred theory to represent the study of knowledge conversion (Hislop, Bosua, & Helms, 2018) is Nonaka's knowledge creation theory (1995) which postulates a knowledge spiral that facilitates the transformation of tacit knowledge into explicit knowledge and then back again as the basis for individual, group, and organisational innovation and learning. The SECI model is a two-dimensional matrix depicting four possible scenarios for interacting or converting tacit and explicit knowledge (see Fig. 1). In essence, the model involves four knowledge conversion processes:

1. Socialisation (S; interaction of tacit to tacit);
2. Externalisation (E; conversion from tacit to explicit);
3. Combination (C; interaction of explicit to explicit); and
4. Internalisation (I; conversion of explicit to tacit).

These four processes do not end with one rotation; instead, they create knowledge by repeating in an ascending knowledge spiral. These processes are elaborated below.

Socialisation is the process of transferring tacit knowledge from one person to another. In the school context, individual tacit knowledge can be shared by several teachers through interaction with environments and the experience of sharing time and space with others (Marra, 2004; see also Cheng, 2018). Tacit knowledge for instruction design can be created when tacit knowledge interacts with other tacit knowledge. Teachers can absorb knowledge from "knowledgeable others" through the socialisation process. Such a situation, in which a group of teachers

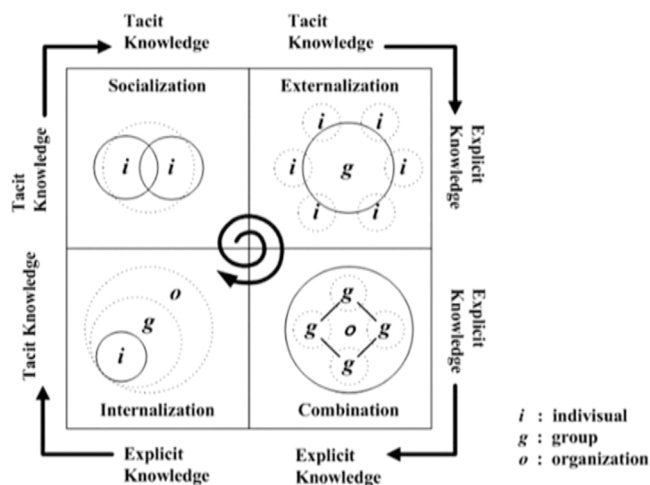


Fig. 1. SECI framework.
Adapted from Cheng (2018, p.30).

practice collaborative lesson planning and evaluation, has been shown to enhance student learning (Marra, 2004). Participation in designing and evaluating lesson plans is a socialisation process through which individual teachers' tacit knowledge can be shared and co-constructed through interaction.

Externalisation is a process of “articulating tacit knowledge into explicit knowledge from dialogue to text records, codifying the tacit knowledge in documents” (see Nonaka & Takeuchi, 1995, p. 71). The knowledge externalisation process happens within collaborative lesson planning meetings where teachers' tacit pedagogical knowledge is converted into explicit knowledge and expressed in analogies, concepts, hypotheses or concrete models in a lesson or unit plan. Through externalisation, tacit knowledge accumulated by teachers can be converted to explicit knowledge via examples through languages and images. While teaching ideas may be ambiguous in individual teachers' minds, through their dialogues, the ideas will become clearer, as the ideas can be objectively understood and visualised in the teaching materials and lesson and unit plans. Often, a new idea for curriculum implementation can be born from this process.

Combination is the process through “which knowledge is systematically integrated into an organisation knowledge system as a knowledge asset” (see Nonaka & Takeuchi, 1995, p. 73). Through knowledge combination, teachers can combine the explicit knowledge of individual departments into more usable school-level teaching knowledge to address the major concerns of the lesson plan. An example of the combination process is the combination of pedagogies and questioning techniques from different subjects. In terms of the curriculum implementation process, knowledge combination is a deliberative design process in which teachers are gathered from different departments to produce specific knowledge by combining data, information and knowledge. In the knowledge combination process, concepts are combined through rational and logical thought, resolving possible contradictions to produce new and more comprehensive knowledge. The combination process happens across different departments, co-creating and eliciting higher-level school knowledge.

Internalisation pertains to how the individual understands and absorbs the collective explicit knowledge through practising that explicit knowledge. It is a mode that converts the externalised organisational knowledge into individual tacit knowledge. The organisation's formal knowledge is iteratively reconstructed, through practice, in combination with one's situation and knowledge. As a result, the internalisation process of accepting it as new “tacit knowledge” happens. Internalisation is approached consciously and subjectively. The knowledge internalisation process involves the concept of “learning by doing; organising explicit knowledge is learned by the individual through their

professional practices” (Nonaka & Takeuchi, 1995, p. 78). Through the internalisation (of explicit knowledge into tacit knowledge), teachers incorporate knowledge into the teaching and learning activities to achieve better student learning outcomes. The teachers who enact the lesson plan and practise the explicit teaching theories can then experience and internalise the explicit knowledge as their tacit knowledge. Enacting the lesson plan is an internalisation process that transfers the school-level or subject-level explicit knowledge to the teacher. As teachers apply the knowledge shared in collaborative lesson planning to their teaching practices, the explicit knowledge is internalised as personal or tacit knowledge (Kolb, 1984).

2. Methods

2.1. Participants

Since primary and secondary school teachers are required to implement the LtoL curriculum, data was collected from 540 teachers in 11 schools, six at primary and five at the secondary level, in Hong Kong. The schools were selected from the list of a school partnership project organised by the authors. The sampling method used was a non-probability sampling where teachers from the schools received an invitation to participate in a research survey. Teachers who consented to participate were thereby included in the study. The average number of teachers per school is 48.18, and the majority are female ($n = 360$, 67.92%). On average, the teachers each have 12.87 years ($SD = 8.47$) years of teaching experience.

2.2. Scale and item development

All items were developed from the literature on SECI processes (Cheng, 2018; Cheng, 2021)) and collaborative lesson planning (e.g., Tammets, Pata, & Laanpere, 2013; Tee & Lee, 2011). In addition, the items were supplemented by questions derived from two focus group interviews with six primary school teachers and one focus group interview with six secondary school teachers to strengthen the content validity of the four constructs in the context of lesson planning. The theory-driven items and interview-based items produced a total of 28 items. The items include statements that evaluate the four SECI processes: socialisation (e.g., *I often ask further questions to know others' views and ideas during “Collaborative Lesson Preparation”*), externalisation (e.g., *When I am expressing conceptions that are relatively abstract, I will use real examples to explain*), combination (e.g., *I organise my teaching experiences which are ambiguous and manage a set of teaching belief to share with others*), and internalisation (e.g., *I often transform those preliminary teaching ideas into some concrete viewpoints for sharing*). Teachers can indicate their agreement to each of the items/statements on a six-point Likert scale: 1 = “strongly disagree”, 2 = “disagree”, 3 = “slightly disagree”, 4 = “slightly agree”, 5 = “agree”, and 6 = “strongly agree”.

The items were reviewed by a panel of three experts in knowledge management and collaborative lesson planning to examine their face validity and content validity. The criteria for selecting the content experts include having worked in the field of education with specialisation on teacher professional development of at least ten years and having conducted and published studies on knowledge management. The experts were invited through emails to comment on whether the items describe the four knowledge convention processes and the four knowledge conversion processes contextualised in teacher collaborative lesson planning. Although the experts are knowledgeable on the concept of collaborative lesson planning, they were provided with a brief description of the study that includes the definitions of concepts and processes (e.g., tacit and explicit knowledge, convention and conversion processes, collaborative lesson planning, and the SECI model).

Items measuring outside classroom teaching activities were modified based on the panel's suggestions. We then pilot-tested the instrument with a group of primary and secondary teachers ($n = 20$) facilitating

Lesson Study to promote collaborative teacher learning addressing the LoTL curriculum. To minimise class interruptions, the selection of teachers for pilot-testing was based on availability and interest to take part in the research. The participants of the pilot testing were asked to review the items in terms of clarity, potential ambiguity, and bias. The items related to student guidance were further refined or discarded based on suggestions by participating teachers.

2.3. Procedures

The authors' affiliated institution approved the procedures of this study. A cross-sectional quantitative survey was designed to collect data from six primary and five secondary schools participating in a government-funded project. Each participating school has established a committee to organise the collaborative lesson planning activities. The Education Bureau requires them to formulate a teaching and learning plan for implementing the Learning to Learn curriculum. The teachers completed the 28-item CLPS after the project.

2.4. Data analysis

Following the 5% rule on missing data (Tabachnick, Fidell, & Ullman, 2007), participants with more than 5% of item-level missing data ($n = 13$) were excluded from the analysis. The remaining responses with item-level missing data were imputed using multiple imputations by chained equations (Azur, Stuart, Frangakis, & Leaf, 2011). Multivariate outliers (i.e., participants with extreme scores on multiple items or variables), which might bias the parameter estimates (Kline, 2015; see also Meade & Craig, 2012), were identified using the Mahalanobis distance rule. Identified outliers with item-level scores $> 0.1\%$ away from the centroid ($n = 39$) were excluded from the analysis. A total of $n = 488$ responses were used in the analysis. The data is randomly split into two halves: $n = 244$ for the exploratory factor analysis (EFA) and the other half for the confirmatory factor analysis (CFA) and Rasch analysis.

EFA with promax rotation was conducted to explore the underlying structure of the items. Parallel analysis and scree plot method were used to identify the potential number of factors. The standardised loadings from the pattern matrix of the EFA factor structure were interpreted using a factor loading cutoff of at least .40 and no cross-loading (i.e., item loading $> .30$ in other factors). Total variance explained by factor analysis of 60% is deemed sufficient (Hair, Black, Babin, & Anderson, 2010). The correlation and internal consistency of the factors were also computed.

The analytical approach of combining CFA and Rasch analysis has been implemented in recent studies (e.g., Chang & Engelhard, 2016; Mendoza & Yan, 2021; Testa et al., 2019; West et al., 2020; Yan, 2018, 2020) because both analyses provide complementary information regarding the instrument's psychometric properties.

CFA was implemented to test the derived factor structure from the EFA using Rosseel's (2012) lavaan package. We used the maximum likelihood estimator with robust standard errors, and a Satorra-Bentler scaled test statistic to test the CFA. Satorra-Bentler chi-square tests (χ^2) and robust fit indices were obtained. We then compared the fit indices of the factor structure from the EFA against a general one-factor model. Several goodness-of-fit indices were evaluated: Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and standardised root mean square residual (SRMR). Hu and Bentler's (1995) recommendations were followed where a good model fit would include a CFI and TLI of greater than 0.90 and an RMSEA of less than .08. An SRMR value less than .08 is considered a good fit, and .00 is a perfect fit (Hu & Bentler, 1999). The p-value of the $SB\chi^2$ was not material to the model fit since the sample size for the CFA is larger than 200 (Barrett, 2007).

Since CLPS contains four inter-correlated subscales, a multidimensional Rasch-based model (Adams, Wilson, & Wang, 1997), using

ConQuest 2.0 (Wu, Adams, Wilson, & Haldane, 2007), was applied to check the dimensionality of the scale and item fit statistics. In the multidimensional Rasch analysis, all subscales are calibrated simultaneously, and the subscale inter-correlations are used to enhance the measurement precision on each subscale (Bond, Yan, & Heene, 2020). The indicators used to examine the psychometric properties of the instrument included Rasch reliability, response category functioning, and item fit statistics (i.e., Infit MNSQ and Outfit MNSQ).

3. Results

3.1. Exploratory factor analysis

Using the randomly selected half of the sample ($n = 244$), the Kaiser-Meyer-Olkin (KMO) = .96 and Bartlett's test of sphericity χ^2 (465) = 5612.13, $p < .001$ indicate that the sample is adequate for factor analysis. The parallel analysis suggests three factors, although the scree plot visually suggests the possibility of four factors. To resolve the potential number of factors for the EFA, we evaluated the model fit indices of a three-factor and four-factor structure. This method is used to determine the optimal number of factors for EFA (see Finch, 2020). Comparing the EFA fit indices, results suggest that the four-factor structure [χ^2 (347) = 668.55, CFI = .943, TLI = .915, RMSEA = .061, SRMR = .03] has a better model fit than the three-factor structure [χ^2 (375) = 793.75, CFI = .924, TLI = .898, RMSEA = .068, SRMR = .04]. Table 1 shows the items loaded on each factor: factor 1 (7 items; $\alpha = .93$), factor 2 (3 items; $\alpha = .84$), factor 3 (7 items; $\alpha = .87$), and factor 4 (6 items; $\alpha = .91$). Seven items which were low in factor loading (i.e., factor loading $< .40$) and cross-loading (i.e., factor loading $> .30$) were excluded. Based on the content of the items and the a priori SECI model, factors 1–4 are labelled as socialisation, externalisation, combination, and internalisation, respectively. The four factors account for a cumulative variance of 58%, and the intercorrelations among the factors were moderately correlated ($r = .65$ to $.71$). The 23-item scale (CLPS-23) has internal reliability of $\alpha = .96$. To confirm the dimensions of the EFA, a CFA complemented with a multidimensional Rasch analysis was conducted.

3.2. Confirmatory factor analysis

We then assessed the structural validity of the four-factor CLPS-23 through a CFA. We tested the four-factor model using the other randomly selected half of the sample ($n = 244$) using the 23 items identified in the EFA. All items were treated as continuous data with maximum-likelihood as the estimation method. The four-factor model showed good model fit with the data $SB\chi^2$ (224) = 474.33, CFI = .905, TLI = .915, RMSEA = .074, SRMR = .044 (see Fig. 2 and Table 2 for standardised factor loadings of the CFA). In the subsequent Rasch analysis, we found two items (items 11 and 18) that did not fit well. Hence, we removed these two items and re-evaluated the four-factor structure of the CLPS and compared it to the original four-factor structure with 23 items. The updated CFA results suggest that the four-factor structure with the updated 21 items yielded a statistically better model fit [$SB\chi^2$ (183) = 368.92, CFI = .922, TLI = .932, RMSEA = .071, SRMR = .038] than the four-factor structure with 23 items ($\chi^2_{diff} = 105.51$, $p > 0.001$).

3.3. Rasch analysis

The multidimensional Rasch analysis results supported the four-factor structure of the CLPS. The preliminary Rasch analysis on the 23-item scale identified one item in *Combination* (Item 11: I will organise my teaching experiences which are ambiguous and manage a set of teaching beliefs to share with others) and one item in *Internalisation* (Item 18: I often apply the opinions collected from "Collaborative Lesson Preparation" to those teaching difficulties I encountered) as showing

Table 1
Exploratory factor analysis of the CLPS: Pattern matrix with promax rotation.

CLP items	Factor 1	Factor 2	Factor 3	Factor 4
1. I can reach consensus with other members of the teaching team on students' learning difficulties in different teaching topics.	0.14	0.40	0.12	0.20
2. The whole teaching team has the same pursuit on the professional views and impression with regard to improving students' learning difficulties.	0.23	0.40	0.07	0.21
3. Members of the teaching team often share with others their knowledge and experience in teaching actively during "Collaborative Lesson Preparation".	0.10	0.63	0.15	-0.02
4. When one member in the teaching team has questions and asks other members, other members will try their best to answer the questions.	0.19	0.79	-0.01	-0.14
5. Majority of the members in the teaching team accept and are positive towards new conceptions or ways of thinking.	0.08	0.90	-0.04	-0.12
6. When members of the teaching team are discussing, they will try their best to provide their own opinions.	-0.12	0.72	0.24	0.00
7. Majority of the members of the teaching team can clearly explain and describe their own points of view.	-0.23	0.69	0.23	0.18
8. When members of the teaching team do not understand my meaning, I can often try to explain with concrete proofs.	0.28	0.14	-0.17	0.56
9. I often transform those preliminary teaching ideas into some concrete viewpoints for sharing.	-0.03	-0.08	-0.05	0.96
10. I can transform teaching theories into simpler verbal narration to help with the communication among members of the teaching team.	0.01	-0.10	0.14	0.78
11. I organise my teaching experiences which are ambiguous and manage a set of teaching beliefs to share with others	0.41	-0.17	0.17	0.16
12. I often organise and generalise others' ideas in my mind in teaching meetings	0.67	-0.04	0.01	0.10
13. I will seriously listen to and adopt the opinions given by observers, which can help improve my teaching.	0.74	0.07	0.13	-0.21
14. I will compare those new teaching methods I know with my existing experience in order to understand the meaning of those methods	0.77	0.05	-0.12	0.03
15. I will not feel ashamed to ask so as to clarify the teaching viewpoints expressed by others	0.44	0.10	-0.08	0.24
16. I will share my viewpoints with others in order to find out if my understanding is thorough enough	0.54	0.20	0.03	0.11
17. I will share my teaching experience with others actively during "Collaborative Lesson Preparation."	0.41	0.20	-0.02	0.21
18. I often apply the opinions collected from "Collaborative Lesson Preparation" to those teaching difficulties I encountered	0.24	-0.05	0.64	-0.21
19. Members of the teaching team have an in-depth cognition of the teaching target and task of their subject through "Collaborative Lesson Preparation."	0.13	0.20	0.63	-0.04
	-0.11	0.18	0.72	0.13

Table 1 (continued)

CLP items	Factor 1	Factor 2	Factor 3	Factor 4
20. Members of the teaching team develop better teaching skills through "Collaborative Lesson Preparation".				
21. Members of the team can effectively link up and make use of the teaching knowledge through "Collaborative Lesson Preparation."	-0.10	0.18	0.66	0.15
22. The lesson implementation after "Collaborative Lesson Preparation" can assist me in internalising the teaching information into my individual knowledge.	-0.01	0.13	0.52	0.17
23. Collaborative Lesson Preparation" helps me integrate my individual knowledge into the teaching team, which can enhance the performance of the team.	-0.07	0.25	0.58	0.12
Proportion variance explained	0.18	0.17	0.15	0.11
Eigenvalues/Sums of Squares loadings	5.31	5.08	4.43	3.18

Notes. ^aItem excluded considering the item-misfit from the Rasch analysis.

misfit to the Rasch model. The values of Infit/Outfit MNSQ of these two items were 1.54/1.43 and 1.55/1.52, respectively. Judging from the acceptable range between 0.75 and 1.33 of MNSQ statistics (Wilson, 2005), these two items demonstrated underfit (MNSQ statistics > 1.33), indicating they probably measured something different from that measured by other items in the same subscale. Hence, these two items were removed, and the Rasch analysis was re-run. All the remaining 21 items, with one exception, had sufficient fit to the Rasch model, suggesting that each item assessed the latent trait as hypothesised. The exceptional item was Item 19 in *internalisation*. Its Infit and Outfit MNSQ were 0.73 and 0.63, respectively, indicating marginal overfit (MNSQ statistics < 0.75). Considering that the current study is the first validation of the CLPS and overfit is less detrimental than underfit (Bond et al., 2020), this item was kept. The six-point response scale functioned well as the step calibrations (i.e., the measures of the transition points between adjacent categories) increased monotonically from -5.26, -3.18, -1.48, 2.39, to 7.53 logits. The four subscales, including Socialisation, Externalisation, Combination, and Internalisation, had satisfactory Rasch reliabilities: 0.93, 0.85, 0.90, and 0.93, respectively.

4. Discussion

The current study aimed to fill the research gap pointing at the need for a theoretically sound instrument to evaluate teachers' collaborative lesson planning (CLP). Applying the SECI knowledge creation framework, the study empirically validated a theory-driven instrument for assessing teachers' CLP. The findings from the EFA identified four underlying factors that explained 58% of the variance of the scale, which is considered acceptable (see Hair et al., 2010). The complementary CFA and Rasch analysis further verify the four factors identified by the EFA. In line with the SECI theoretical framework, the four factors were labelled socialisation (7 items), externalisation (3 items), combination (6 items), and internalisation (5 items), completing the 21-item CLP scale.

The knowledge socialisation scale measures how the teachers can share their tacit knowledge, experience, and opinions in teaching activities during collaborative lesson preparation and clearly explains and describes their points of view. The higher the scores, the more they articulate their answers to other questions. They accept and are positive regarding new conceptions or ways of abstract thinking. They can pursue professional views and impressions that reach a consensus to reduce students' learning difficulties in different teaching topics. This finding suggests that socialisation in the context of collaborative lesson preparation enables teachers to learn the pedagogies and professional

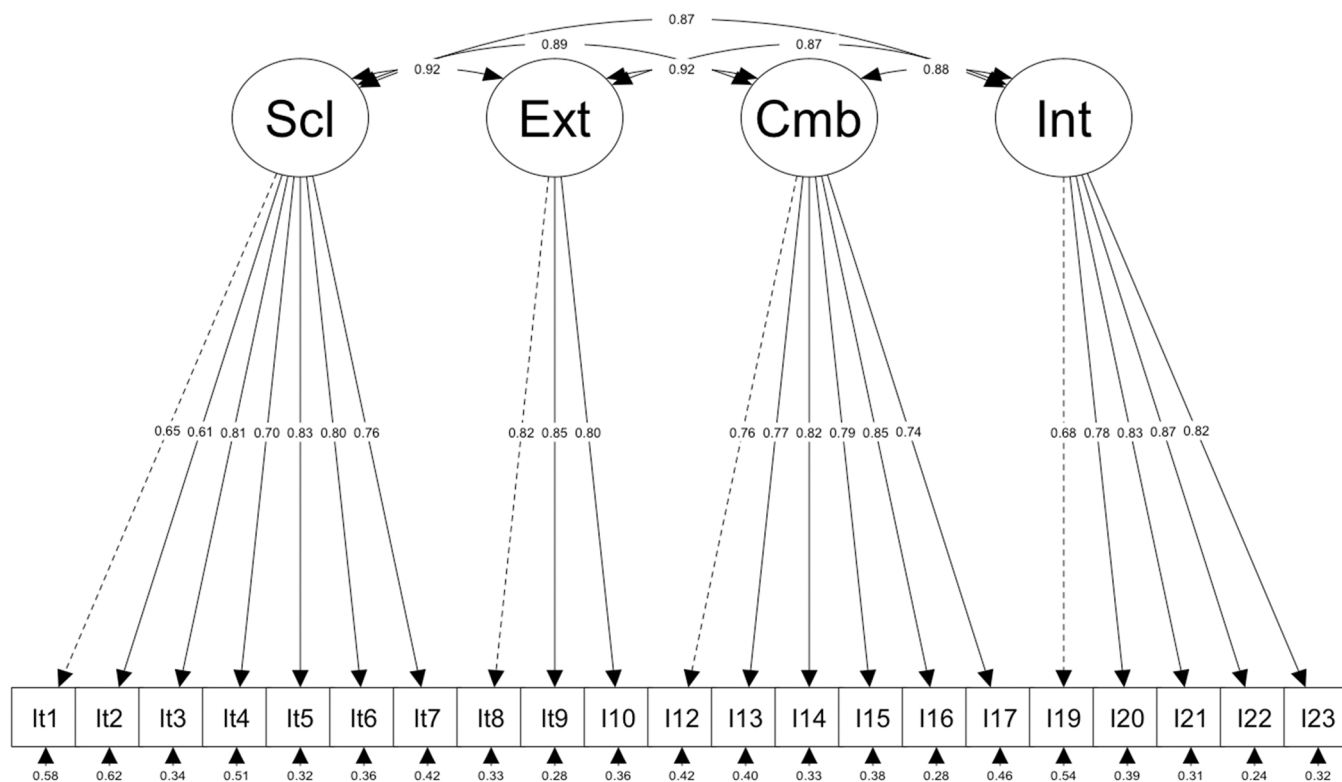


Fig. 2. Four-factor structure of CLPS-21 and its standardised factor loadings. Scl = socialisation, Ext = externalisation, Cmb = combination, Int = internalisation.

practices collaboratively. This finding echoes the study of Williams (2010), highlighting that the teachers learn from the perspectives of their co-teachers to implement elements from their lessons into their teaching.

The knowledge externalisation scale measures how the teachers can transform those preliminary teaching ideas into concrete viewpoints for sharing and explaining with concrete proofs. They can leverage their teaching theories into simpler verbal narration or lesson plans and teaching materials to help with communication among members of the teaching team. Teachers reflect on their implicit teaching experiences and effective pedagogical practices in explicit form, often written knowledge, that can be shared with collaborating teachers.

The knowledge combination process measures how the teachers organise and generalise their collective teaching experiences, which are ambiguous, with a set of subject-based teaching beliefs, to share with others. They listen to and adopt observers’ opinions and compare those new teaching methods they know to better understand the meaning of those methods. They shared their viewpoints with others to verify whether their understanding was thorough, and they did not feel ashamed to ask for clarification of the teaching viewpoints expressed by others. Such professional attitudes break down the barrier of the subject knowledge boundary of teachers and help them co-create school level pedagogical knowledge that can be applied in different subjects to improve the intended learning outcome of the LtoL curriculum. The validation of the knowledge externalisation and combination processes echoes the assertions of Gutierrez (2021) and Vescio, Ross, & Adams (2008) that teachers’ collaborative lesson planning is associated with their instructional practices.

The knowledge internalisation process measures the extent to which the teachers can internalise and apply the collective teaching information acquired through collaborative lesson preparation into their individual knowledge for solving teaching-related problems. The higher the score, the more they can effectively link up the teaching knowledge and use it to develop better teaching skills. They have an in-depth cognition of the teaching targets and tasks of their subject and integrate their

individual knowledge into the teaching team, which can enhance the performance of the team. These findings are similar to the assertion of Eaker, DuFour, & Burnette (2002) on teacher collaboration: that teacher reflection on their instructional practices, goal setting, and pedagogical framing aids effective lesson delivery.

The overall findings of this empirical model reproduce the function of CLP practices to enhance reflective teacher learning through a cyclic framework advocated by Gutierrez (2021). In addition, these findings expand the scope of application of the SECI model from strategic planning (Cheng, 2021) to teacher collaborative lesson preparation. Using the SECI model as the analytical framework, the findings illustrate teacher collaborative learning and professional practices in their collaborative lesson preparation. These practices complement recent research highlighting how teachers organise and reflect on prior knowledge to develop new knowledge that could be refined and enacted in the classroom (Eaker, DuFour, & Burnette, 2002; Gutierrez, 2021). The findings also portray teacher professional growth through knowledge sharing and internalisation through collaborative lesson preparation for curriculum implementation. Thus, CLP enables teachers to pursue and realise their professionalism.

Of note, two items were identified by the Rasch analysis as item misfits under their underlying dimension or factor. The misfit of item 11 (“I organise my teaching experiences which are ambiguous and manage a set of teaching beliefs to share with others”, under combination) might be because organising ambiguous teaching experiences and managing a set of teaching beliefs for knowledge sharing are indicators for externalisation process and combination process respectively, and should be addressed separately. For item 18 (“I often apply the opinions collected from collaborative lesson planning to those teaching difficulties I encountered”, under externalisation), the opinions collected through collaborative lesson preparation might have limitations for direct application to the class, with different contexts and subject boundaries. Therefore, teachers found it challenging to internalise it. It is possible that items focused on applying the pedagogies developed by peer lesson observations could result in a more optimal fit to the externalisation of

Table 2
CFA factor loadings and Rasch item difficulties and item fit Statistics of the CLPS.

Scale/Item	CFA Factor loadings	Rasch Item Measure*	SE	Infit MNSQ	Outfit MNSQ
<i>Socialisation</i>					
1. I can reach consensus with other members of the teaching team on students' learning difficulties in different teaching topics.	–	0.28	0.10	1.03	0.99
2. The whole teaching team has the same pursuit on the professional views and impression with regard to improving students' learning difficulties.	0.61	0.47	0.10	1.12	1.17
3. Members of the teaching team often share with others their knowledge and experience in teaching actively during "Collaborative Lesson Preparation".	0.81	0.26	0.10	0.98	1.01
4. When one member in the teaching team has questions and asks other members, other members will try their best to answer the questions.	0.70	-0.86	0.10	0.91	0.85
5. Majority of the members in the teaching team accept and are positive towards new conceptions or ways of thinking.	0.83	-0.33	0.10	1.00	0.97
6. When members of the teaching team are discussing, they will try their best to provide their own opinions.	0.80	-0.02	0.10	0.83	0.82
7. Majority of the members of the teaching team can clearly explain and describe their own points of view.	0.76	0.20	0.24	0.94	0.96
<i>Externalisation</i>					
8. When members of the teaching team do not understand my meaning, I can often try to explain with concrete proofs.	–	-0.92	0.09	0.90	0.92
9. I often transform those preliminary teaching ideas into some concrete viewpoints for sharing.	0.85	0.62	0.09	0.90	0.95
10. I can transform teaching theories into simpler verbal narration to help with the communication among members of the teaching team.	0.80	0.30	0.13	1.13	1.13
<i>Combination</i>					
12. I often organise and generalise others' ideas in my mind in teaching meetings	–	0.48	0.10	1.09	1.13
	0.77	-0.73	0.10	1.02	0.97

Table 2 (continued)

Scale/Item	CFA Factor loadings	Rasch Item Measure*	SE	Infit MNSQ	Outfit MNSQ
13. I will seriously listen to and adopt the opinions given by observers, which can help improve my teaching.					
14. I will compare those new teaching methods I know with my existing experience in order to understand the meaning of those methods	0.82	-0.02	0.10	1.05	1.05
15. I will not feel ashamed to ask so as to clarify the teaching viewpoints expressed by others	0.79	0.48	0.10	1.18	1.22
16. I will share my viewpoints with others in order to find out if my understanding is thorough enough	0.85	-0.05	0.10	1.15	1.15
17. I will share my teaching experience with others actively during "Collaborative Lesson Preparation."	0.74	-0.17	0.22	1.16	1.16
<i>Internalisation</i>					
19. Members of the teaching team have an in-depth cognition of the teaching target and task of their subject through "Collaborative Lesson Preparation."	–	-0.11	0.10	0.73	0.63
20. Members of the teaching team develop better teaching skills through "Collaborative Lesson Preparation".	0.78	0.00	0.10	0.75	0.76
21. Members of the team can effectively link up and make use of the teaching knowledge through "Collaborative Lesson Preparation."	0.83	-0.02	0.10	0.92	0.89
22. The lesson implementation after "Collaborative Lesson Preparation" can assist me in internalising the teaching information into my individual knowledge.	0.87	0.00	0.10	0.87	0.85
23. Collaborative Lesson Preparation" helps me integrate my individual knowledge into the teaching team, which can enhance the performance of the team.	0.82	0.12	0.19	0.92	0.91

Note. *All measures and SEs are in logits; item 11 and item 18 (see Table 1) are excluded.

CLP. Still, the development of CLPS fills the gap of lacking an instrument that can evaluate teachers' collaborative lesson planning practices. This is an important step towards the further evaluation, monitoring, and development of CLP practices among teachers in schools, especially in contexts where curriculum reforms demand the collaborative effort of teachers to help students fulfil their learning needs.

4.1. Implications

The CLPS can be used to evaluate teachers' participation in CLP for instructional design. Specifically, schools may administer the CLPS to teachers before, during, or after CLP implementation to evaluate how teachers' CLP practices develop over time. The information collected from the CLPS can aid the development of pedagogies for curriculum implementation, address the obstacles and challenges when CLP practices are observed to be low, and enhance school-level policies that may attenuate teachers' use of CLP practices. In addition, the items on the CLPS can be adapted and modified to identify a specific context that CLP practices are targeting. For instance, if a school wishes to evaluate teachers' CLP practices specific to STEM teaching, items can be adjusted to include "STEM teaching" in the instrument statements. Doing so allows the CLPS to be a context-specific instrument that can be applied across different teaching domains.

4.2. Study limitations and future research directions

Despite this study being the first to develop and validate an instrument for collaborative lesson planning using data from teachers in the context of a progressive educational curriculum, we note study limitations that could be explored in future research endeavours. First, although our data was collected from both primary and secondary schools, our study used convenience sampling, which may not represent teachers from other schools not covered in this study. Since all participating teachers are from public schools, future research can also explore testing the instrument's factor structure using data from private or international schools. Moreover, examining the instrument's validity in other contexts and cultures is also worthy of future research. Second, our complementary Rasch analysis found two items to exhibit poor item fit under their latent factor. However, this could be due to the potential overlap present within the SECI framework. Although the 21-item CLPS has sufficient internal psychometric properties, researchers may explore how these items perform statistically in future studies. Aligned with further work in improving the psychometric properties of the CLPS, the second-factor externalisation had the lowest internal reliability of all factors. As there are only three items under the externalisation subscale, more specific CLP practices that fall under externalisation could be developed in future research endeavours. Third, given that the instrument is self- or teacher-reported, assessment of collaborative lesson planning can also be supplemented by the principal or observational reports. Future studies can explore methods to capture principal-reported collaborative lesson planning, such as institutional checklists and inventories.

Similarly, including brief instruments to assess social desirability bias in data collection can also help navigate the bias inherent in self-report surveys. Finally, although this study provided evidence of content validity and factor structure of the CLPS, future work must examine other aspects of validity. For instance, regressing related constructs to CLPS can support its convergent or concurrent validity, and administering the instrument at two separate time points can support its test-retest reliability.

5. Conclusion

Collaborative lesson planning is a sustainable professional development strategy for teachers. Especially in contexts where curriculum development is at the forefront of educational reform, a sustainable professional development strategy like CLP is crucial for teachers to effectively and efficiently respond to the increasing demands of teaching. The CLPS developed in this study provides a useful tool for assessing, monitoring and developing teachers' collaborative lesson planning practices. The reliability and validity evidence provided by factor analyses and Rasch analysis lends credence to the use of the CLPS for primary and secondary school teachers. The insights that could be drawn

from the use of the CLPS can inform the design of teacher professional development programmes and facilitate the creation of a community of practice within schools that can aid pedagogy and respond to curriculum reforms.

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