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ORIGINAL PAPER

Psychometric properties of a Chinese version of the Constructivist Learning Environment Survey among secondary-school students in Hong Kong

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Abstract
The study examined the factor structure, reliability and validity of a Chinese version of the Constructivist Learning Environment Survey (C-CLES), an instrument for assessing students' perceptions of the extent of constructivist approaches prevalent in classrooms. A convenience sample of 967 students in Secondary Three (Grade 9) in Hong Kong participated in this study by completing a self-administered questionnaire in their class time. Exploratory and confirmatory factor analyses supported the hypothesised factor structure, indicating five theoretical constructivist environment dimensions that showed goodness-of-fit to 25 items: Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation. Criterion-related validity, involving evidence based on relations to other variables, was assessed by correlations between the constructivist environment dimensions and cognitive strategies and academic ability. Most correlations were statistically significant and in the positive direction. The C-CLES with 25 items provides a useful measure for educational practice and research among school students.

Keywords Cognitive outcomes · Constructivist learning environment · Secondary schools · Validation

Introduction

Constructivists believe that knowledge is not imposed from outside but constructed inside individuals. Compared with the superficial learning in traditional classrooms, constructivist learning environments focus on deeper understanding via high involvement of students' ideas (Schunk 2015). Therefore, curriculum reforms over the world aim at developing students' in-depth understanding and higher-order thinking, enthusiastically advocating the incorporation of constructivist-oriented principles into teaching and learning in classrooms. For instance, the Government of the Hong Kong Special Administrative Region has launched a curriculum and assessment curriculum (CDC 2000) which includes a new

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curriculum framework—*Learning to Learn*—emphasising generic skills, such as critical thinking, creativity and problem solving.

Curriculum Guide (CDC 2009) highlights classroom environments with high-quality interaction among students and teachers and learning communities for knowledge building are highlighted. Collaborative practices encouraged among teachers and students include "agreeing to a common learning agenda", "active participation, belonging, collaboration and dialogue" and "sharing responsibility for knowledge building" (p. 17). In particular, these suggestions about adopting pedagogical approach of co-construction of knowledge among teachers and students are in line with constructivist principles are encouraged.

Although there are a number of established measures of learning environment for students in the literature (e.g., Individualised Classroom Environment Questionnaire and What Is Happening In this Class? (for details of these instruments, refer to Fraser 2012), there are few instruments like Constructivist Learning Environment Survey (CLES) that are explicitly and theoretically based on constructivism. The CLES has been adopted in a number of studies of learning environment under new education reform initiatives (e.g., Anagün 2018; Johnson and McClure 2004; Wong et al. 2010). One of the instructional principles under the education reform in Hong Kong is to develop students' in-depth understanding through constructivist-oriented learning environments. A review of local literature identified very few studies of the extent to which constructivist learning environments are being implemented under curriculum reform (Yip 1998).

Constructivist Learning Environment Survey (CLES)

The CLES was first developed in 1991 (Taylor and Fraser 1991) and then revised in 1997 (Taylor et al. 1997) to incorporate the perspective of critical constructivism. Then the total number of items in the revised CLES was increased from 28 to 30 items with five six-item scales. The revised CLES (referred to as CLES30 hereafter to indicate the revised version with a total of 30 items) assesses five dimensions—Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation—which distinguish constructivist learning environments from conventional ones.

The scale of Personal Relevance refers to the extent to which teachers relate the subject matter to students' out of-school experiences. A sample item is "I get a better understanding of the world outside of school" (Aldridge et al. 2000, p. 39). The Uncertainty scale identifies the extent to which opportunities are provided for students to experience subject knowledge as arising from theory-dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined. A sample item is "I learn that Science cannot provide perfect answers to problems" (Aldridge et al. 2000 p. 39). The Critical Voice scale refers to extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans and methods and to express concerns about any impediments to their learning. A sample item is "It's OK for me to ask the teacher 'why do I have to learn this?'" (Aldridge et al. 2000, p. 39). The Shared Control scale measures the extent to which students are invited to share with the teacher control of the learning environment, including the articulation of their own learning goals, design and management of their learning activities, and determination and application of assessment criteria. A sample item is "I help the teacher to plan what I'm going to learn" (Aldridge et al. 2000, p. 39). Finally, the Student Negotiation scale assesses the extent to which opportunities exist for students to explain and justify to other students their newly-developing ideas and to listen and reflect

on the viability of other students' ideas. A sample item is "I get the chance to talk to other students" (Aldridge et al. 2000, p. 39).

The CLES30 has been used widely in various studies including high-school science and mathematics classrooms in Australia (Dryden and Fraser 1998). It has also been modified to fit the assessment of specific learning situations, such as adaptation to form the Constructivist On-line Learning Environment Survey for online environments (Taylor and Maor 2000), a version for comparing students' perceptions of teachers who had been trained for using constructivist principles and those who had not (Nix et al. 2005), and a version for evaluating the extent to which practices in a teacher preparation program align with characteristics of a constructivist learning environment (Harrington and Enochs 2009).

Johnson and McClure (2004) shortened the CLES30 to 20 items [called CLES2(20)] because some items had a factor loading less than 0.4 and were found to be redundant and unclear. Thus, items found to be confusing and redundant by teacher participants were either removed or rewritten. For example, Item 12 ("I learn that science is about inventing theories") from the Uncertainty scale was removed, and Item 2 ("New learning starts with problems about the world outside of school" from the Personal Relevance scale was rewritten to "New learning relates to experiences or questions about the world inside and outside of school". However, some of these rewritten items were problematic. Eventually the CLES2(20) retained five scales with four items per scale. The reliabilities of these five scales in two studies of 110 and 354 upper-elementary, middle- and high-school students in US ranged from 0.72 to 0.89 and from 0.76 to 0.90, respectively (Johnson and McClure 2004). The alpha reliability of the total CLES2(20) instrument was 0.93 and 0.94, respectively. (An alpha exceeding 0.92 indicates a possibility of item content overlapping.) To replicate findings of the past studies, Ozkal et al. (2009) adapted CLES2(20) to assess elementary-school students' perceptions of constructivist learning environments in Turkey. The internal consistencies of the five dimensions in their study ranged from 0.57 to 0.74, suggesting relatively lower reliabilities than those reported in Johnson and McClure's (2004) study. The low reliabilities were understandable for a scale with fewer items, such as four items per scale in CLES2(20) (deVellis 2016).

Ebrahimi (2015) translated the CLES30 into Iranian for English-language student teachers. This Iranian version was refined to 25 items to obtain satisfactory factorial validity and internal consistency. After validating a version for primary-school teachers in Turkey, Anagun and Anilan (2013) shortened the CLES to 18 items in six scales. In summary, the findings of validation studies for CLES30 were mixed for the various language versions.

To address this study's objectives, the CLES30 by Aldridge et al. (2000) was chosen. The CLES30 has been widely used in measuring classroom environments that are under education reform and emphasise constructivist teaching and learning. It has been translated, modified and used in different countries—a Korean version for science lessons in Korea (Kim et al. 1999), a Chinese version for science lessons for a comparative study between Taiwan and Australia (Aldridge et al. 2000), a Thai version for tertiary computer courses in Thailand (Wanpen and Fisher 2006), Turkish versions for science education (Bas 2012; Ozkal et al. 2009) and primary school teachers (Anagun and Anilan 2013) in Turkey, a Malaysian version for ICT in Malaysia (Wong et al. 2010), and a English-language teacher-education version in Iran (Ebrahimi 2015). For these studies, various modifications to CLES30 were reported.

Generally speaking, previous studies using CLES30 (e.g., Aldridge et al. 2000; Kim et al. 1999; Nix et al. 2005; Taylor et al. 1997; Wong et al. 2010) reported validation information for the CLES in terms of factorial validity by exploratory factor analysis, reliability

by alpha coefficient, discriminate validity by inter-scale correlations, and ability to differentiate between classrooms by η^2 statistic. For example, Wong et al. (2010) translated and modified CLES30 into a 25-item Malaysian version for ICT students. They established face validity through experts, a five-factor solution using Varimax rotation was confirmed and explained a total of 53.81% of the variance, the reliabilities for the five factors ranged from 0.64 to 0.086, the ability of scales to differentiate between classes using the η^2 statistic ranged from 0.08 to 0.12, and the discriminate validity based on inter-scale correlations ranged from 0.26 to 0.52. Based on these findings, the Malaysian version was reported as a reliable and valid measure.

However, although the above statistics and exploratory factor analysis results in previous research supported the reliability and validity of CLES30, there are few studies that have validated it by confirmatory factor analysis and established its criterion-related validity. Exploratory factor analysis can provide information about how and to what extent the observed variables are linked to their underlying factors, while confirmatory factor analysis can test whether the hypothesised relations between the observed variables and the underlying factors exist (Byrne 2016). Criterion-related validity is a confirmatory measure that helps to establish the trustworthiness of results from a test and it assesses the extent to which a test is related to some criterion. Concurrent validity is one type of criterion-related validity that concerns how well a test estimates present performance (deVellis 2016). Therefore, this study extended previous research by providing additional validation information about the CLES30 and testing its priori structure with a sample of secondary-school students in Hong Kong, especially by confirmatory factor analysis and criterion-related validity.

Constructivist learning environment, cognitive strategy and academic ability

In a constructivist learning environment, students are encouraged to deliberately apply metacognitive and cognitive strategies in two possible ways (Tse-Kian 2003). Firstly, students need to actively construct their own understanding by encoding new information with what they have already known. Their metacognitive and cognitive strategies guide this process of knowledge construction. Secondly, social negotiations dominate in a constructivist learning environment. In such an environment, students are required to reason and elaborate their arguments, and to reevaluate their standpoints from others' feedback (Hattie and Timperley 2007). Students internalise these cognitive processes to themselves as strategies of metacognition and cognition (Kuhn and Dean 2004).

It was found that students in a constructivist problem-based learning environment used more deep-processing strategies (complex strategies) and fewer surface-processing strategies (simple strategies) than those in a traditional learning environment (Galand et al. 2003). Another study by Chen (2001) showed that providing a constructivist-oriented learning environment encouraged students to use cognitive and metacognitive strategies. Zohar (1994) found that different learning environments combined with students' preexisting strategies had different effects on students' thinking outcomes. 'Faster' learners seem to improve their learning and thinking strategies in a constructivist learning environment that allows self-discovery. Therefore, students who are in learning environment with more constructivist characteristics tend to have better cognitive strategies.

On the other hand, the constructivist learning environment promotes active learning through connecting new information to existing knowledge. It provokes students to use their existing knowledge actively and productively, so that their knowledge would

provide an anchor to encode new information meaningfully (Krause et al. 2016). Lee and Fraser (2000) found that science-gifted students from a science-independent stream perceived their learning environments as significantly more constructivistic than students of two other streams (humanities and science-oriented) for all CLES scales. Thus, students' perceptions of constructivist learning environment are believed to relate positively to their academic performance.

In Turkey, Kingir et al. (2013) involved a sample of 802 grade 8 middle school students in exploring relationships between constructivist learning environments, motivational beliefs, self-regulation and science achievement. They found that, in classroom environments with higher student autonomy and control, students tend to use more self- regulatory strategies and to have higher academic performance in science. It was observed that constructivist learning environments were correlated with cognitive strategies and academic achievement.

Objectives of the study

This study involved investigating the psychometric properties of a Chinese version of the CLES30 (C-CLES30). Both exploratory and confirmatory factor analyses were conducted to assess construct validity. It adds evidence to the factorial structure of the C-CLES30 and if exists, compares the relative fit of factor models based on the factor analytic findings of the present study. Reliability estimates of the C-CLES and inter-correlations of its scales were be obtained. In addition to checking criterion-related validity, this study examined how different dimensions of constructivist learning environments were associated with elaboration, metacognitive self-regulation and academic performance among secondary-school students.

Method

Participants

Data were obtained from a convenience sample of 967 students enrolled in Secondary Three (i.e., Grades 9) in seven government-aided secondary schools in Hong Kong. The sample included 425 boys (44%) and 539 girls (56%). The age range was from 14 to 18 years and the mean was 14.8 years. Three quarters of the participants studied Liberal Studies while the rest studied Integrated Humanities. Both these subjects at the junior-secondary level served as a preparatory course to Liberal Studies at senior-secondary level. These two school subjects are taught using constructivist instructional approaches, have similar curriculum objectives and content, and schools are free to offer either subject. Therefore, these two school subjects were considered as one (i.e., Liberal Studies) when analysing data in this study. Participants were asked to complete the self-administered questionnaire during the class time.

Constructivist Learning Environment Survey (CLES)

The constructivist learning environment was assessed by a revised Chinese version of Constructivist Learning Environment Survey (CLES), which is in line with critical constructivism and assesses an environment in which learners can construct their knowledge through

communication and critical self-reflection (Taylor 1996). The CLES has five features: Personal Relevance (PR), Uncertainty (UN), Shared Control (SC), Critical Voice (CV) and Student Negotiation (SN) (Aldridge et al. 2000). The Chinese version of CLES30 (referred to as C-CLES30 hereafter to indicate a Chinese version with a total of 30 items) used in this study is modified from the Chinese version in the study of Aldridge et al. (2000). Permission to use the C-CLES30 was obtained from a co-author of the paper (Aldridge et al. 2000) through email.

The CLES was originally designed for the learning environment in science and mathematics classes. Thus, the word "science" in the items was changed to "this subject" to make items more relevant. For example, the item "I learn that science cannot provide perfect answers to problems" in the Uncertainty scale was modified to "I learn that this subject cannot provide perfect answers to problems". All CLES items are responded to using a 5-point frequency scale ranging from 1 (Almost Never) to 5 (Almost Always). One item of the Personal Relevance ("What I learn has nothing to do with my out-of-school life") needs reverse scoring.

Although the scales adopted in this study had been translated into Chinese and validated in Taiwan, it was necessary to check whether the wording of the Chinese version caused confusion to Hong Kong students. The C-CLES30 was pilot-tested with a group of five Grade 9–11 students in Hong Kong who reported that the Chinese wording of some items was ambiguous. Based on feedback from this focus group, the wording of some items was made more specific. For example, for the CLES item "I get the chance to talk to other students", the Chinese meaning of "talk" could be interpreted as informal social talk not related to the lesson or discussion of the assigned topic. Therefore, the word "talk" in this item was replaced by "discuss" in Chinese. This modification was checked to ensure that it was consistent with the meaning of the item in the original version of the CLES.

Scores for items of each scale and all items in the total C-CLES30 instrument were averaged to obtain scores for each of the five scales and one overall score for participants' perceptions of the characteristics of the learning environment. A higher score indicates that an individual perceives that the learning environment has a higher degree of constructivist characteristics.

Motivated Strategies for Learning Questionnaire (MSLQ)

A Chinese version of Motivated Strategies for Learning Questionnaire (MSLQ) (Wu and Cheng 1992) was used to assess cognitive strategies in terms of two aspects: Elaboration and Metacognitive Self-regulation.

The Elaboration scale comprises six items which are scored on a 7-point Likert scale ranging from 1 for Not At All True of Me to 7 for Very True of Me. It measures strategies students use "to store information into long-term memory by building internal connections between items to be learned" (Pintrich et al. 1991, p. 20). A sample item is "I try to relate ideas in this subject to those in other subjects whenever possible". The Elaboration score is the average of the six item scores and a higher score indicates that a respondent is more likely to use strategies to integrate and connect new information with existing knowledge. The internal consistency of this scale in this study was 0.90, showing high reliability.

The Metacognitive Self-regulation scale of MSLQ assesses the control and self-regulation aspects of metacognition rather than the knowledge aspect (Pintrich et al. 1991). This scale includes planning, monitoring and regulating strategies of metacognition. It comprises 12 items and a sample item is "When reading for this subject, I make up questions to

help focus my reading". Participants responded to each item on a 7-point Likert scale ranging from 1 for Not At All True of Me to 7 for Very True of Me. Two items ("During class time, I often miss important points because I'm thinking of other things" and "I often find that I have been reading for this class but don't know what it was all about") are reverse scored. Scores on each item were averaged to obtain a total score for this scale, with higher scores representing higher engagement in planning, monitoring, and regulating metacognitive activities. The alpha reliability of this scale in this study was 0.83, also showing good reliability.

Academic ability

Academic ability of students was measured by scores on the Liberal Studies or Integrated Humanities school examination. Students were asked to report the scores which they obtained in their most recent school examination. The score range is 0–100.

Procedures and data analysis

Approval from the school authority was obtained before carrying out the research. Participants were asked to complete the questionnaire during class period. Teachers were not present during the administration of the questionnaires. Consent was sought from the students who informed them that their participation in the study was on a voluntary basis. The researcher gave the students clear instructions about how to complete the questionnaire before they started to fill it in. Students were reminded that their responses would be kept confidential and were encouraged to answer the questionnaire honestly.

In validating the C-CLES30, analysis of students' responses to the five scales had five steps. First, to ensure the appropriateness of factor analysis for the data, the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's Test of Sphericity were examined, to check that the overall value was greater than 0.60 and was significant. Second, principal components analysis (PCA) with varimax rotation was conducted to examine the factor structure of the instrument. Items were deleted according to the following criteria: low factor loadings (<0.4), high loadings on more than one component (>0.4), low item-total correlations (<0.4) and low communality (<0.5). The PCA was rerun after an item was removed. The PCA was completed when all the criteria listed at the above steps were met. Third, inter-scale correlations and reliability coefficients were computed to examine if the factor structure was affected. Fourth, confirmatory factor analysis (CFA) was performed to test the hypothesised factor structure of the refined measure. Fifth, correlations between other related constructs (i.e., cognitive strategies and academic ability) provided evidence of criterion-related validity.

Results

Exploratory factor analysis (EFA), reliability and confirmatory factor analysis (CFA) of C-CLES30

To test the appropriateness of factor analysis for the data, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were examined. The KMO

value was 0.86, exceeding the recommended value of 0.6 (Kaiser 1974), and Bartlett's Test was statistically significant ($p < 0.001$), demonstrating the factorability of the correlation matrix. PCA revealed the presence of seven components with eigenvalues exceeding 1, explaining 64.27% of the variance. Considering C-CLES30 has a five-scale structure, the analysis was recomputed with a forced solution of five factors which accounted for 56.51% of the variance. Table 1 presents the factor loadings of items and their corresponding factors. Items with loadings of less than 0.30 were removed. The rotated factor matrix shows that most of the items loaded strongly on their hypothesised scale except for three Items 6, 17 and 18. Item 6 in Personal Relevance ("What I learn has nothing to do with my out-of-school life.") was the only negatively-worded item and it had the lowest factor loading (< 0.30) in the whole instrument. Item 17 in the Critical Voice scale ("It' s OK for me to express my opinion") and Item 18 Critical Voice ("It' s OK for me to speak up for my rights") tended to load on Personal Relevance (0.58 and 0.54) and Student Negations (0.36 and 0.37). The factor loadings for these three items also were not high on their hypothesised scale in a previous study by Aldridge et al. (2000) which also used exploratory factor analysis involving PCA with varimax rotation.

Confirmatory factor analysis using maximum likelihood estimation by SPSS AMOS 19 was conducted to examine the replicability of the five-factor solution obtained in the exploratory factor analysis. To evaluate the fit of the model, the Chi squared tests and goodness-of-fit indices were examined. The model Chi square for the five-factor solution with 30 items indicated poor overall fit ($\chi^2(395) = 3505.09$, $p < 0.001$). The Chi square is inflated by large sample sizes like that of in present study ($N = 967$) and therefore significant. When other fit indices were checked, the fit between the data and model was poor (NFI = 0.75, CFI = 0.77 and RMSEA = 0.09). Values of NFI and CFI exceeding 0.90 and of RMSEA less than 0.08 suggest a good-fitting model. Hence, the model fit of the five-factor solution with 30 items of the C-CLES30 was considered unsatisfactory. The standardised path coefficients were all significant and varied from 0.15 to 0.87, and the correlations among the five factors ranged from 0.11 to 0.73. Path coefficients of less than 0.40 and correlations less than 0.30 are considered not meaningful (Blunch 2013; Harrington 2009). Therefore, the construct validity of the C-CLES30 was not satisfactory based on exploratory and confirmatory factor analyses.

Exploratory factor analysis (EFA), reliability and confirmatory factor analysis (CFA) of C-CLES25

After modifications such as deleting four, five and six items were attempted in an attempt to improve the goodness-of-fit of the hypothesised five-factor model, it was concluded that 25 items were most meaningful in supporting the five-factor model. Five items (Items 6, 12, 13, 15 and 16) were removed from the C-CLES30 based on factor loadings, item-total correlations, alpha coefficients when an item was deleted, and path coefficients. Item 6 (Personal Relevance scale) did not load substantially on any factor (i.e., factor loading < 0.3). A corrected item-total correlation is the simple correlation between an item and the sum of the rest of the items. A minimum value of 0.40 for an item-total correlation is a rule of thumb (Blunch 2013). Item 12 (Uncertainty scale) had a very low correlation ($r = 0.28$) and the scale alpha reliability increased substantially (to 0.73) by deleting it. Path coefficients Items 6, 12, 13, 15 and 16 were less than 0.40, suggesting that the latent factor predicted the indicators insufficiently (Harrington 2009). Path coefficients for Items 13, 15 and 16 (both in Critical Voice scale) were 0.29, 0.17 and 0.23, respectively. Although

Table 1 Rotated Factor Matrix for C-CLES (30-item model) based on exploratory factor analyses constrained to five factors

Item	Item wording	Factor loadings				
		1 SC	2 SN	3 PR	4 UN	5 CV
22	I help the teacher to decide how much time I spend on learning activities	0.86				
23	I help the teacher to decide which activities I do	0.86				
21	I help the teacher to decide which activities are best for me	0.85				
20	I help the teacher to decide how well I am learning	0.84				
24	I help the teacher to assess my learning	0.80				
19	I help the teacher to plan what I'm going to learn	0.79				
27	I explain my understandings to other students		0.79			
29	Other students ask me to explain my ideas		0.76			
30	Other students explain their ideas to me		0.76			
28	I ask other students to explain their thoughts		0.75			
26	I talk with other students about how to solve problems		0.75			
25	I get the chance to discuss with other students.		0.69	0.30		
4	I get a better understanding of the world outside of school			0.75		
5	I learn interesting things about the world outside of school			0.70		
1	I learn about the world outside of school			0.70		
2	My new learning starts with problems about the world outside of school			0.56		
3	I learn how this subject can be part of my out-of-school life			0.55		
6	What I learn has nothing to do with my out-of-school life					-0.28
9	I learn that this subject is influenced by people's values and opinions				0.73	
10	I learn about different knowledge of this subject used by people in other cultures				0.71	
8	I learn that this subject has changed over time				0.70	
7	I learn that this subject cannot provide perfect answers to problems				0.60	
11	I learn that this subject is different from that of long ago				0.57	
12	I learn that this subject is about creating theories				0.43	
17	It' s OK for me to express my opinion		0.36	0.58		

Table 1 (continued)

Item	Item wording	Factor loadings				
		1 SC	2 SN	3 PR	4 UN	5 CV
18	It' s OK for me to speak up for my rights		0.37	0.54		
15	It' s OK for me to complain about teaching activities that are confusing					0.79
13	It' s OK for me to ask the teacher 'why do I have to learn this?'					0.76
16	It' s OK for me to complain about anything that prevents me from learning					0.75
14	It' s OK for me to question the way I'm being taught					0.73
	Eigenvalue	7.48	3.46	2.36	1.89	1.77
	Percentage of variance	15.20	13.20	10.76	8.91	8.45
	Cumulative percentage of variance	15.20	28.39	39.15	48.06	56.51

Items with loadings of less than 0.30 were eliminated except for Item 47

the path coefficient for Item 14 (Critical Voice scale) was 0.33, indicating a value less than 0.40, it was finally retained because the Critical Voice scale would have contained only three items. In particular, the corrected item-total correlation for Item 14 was satisfactory ($r = 0.59$).

After the five items were removed from the instrument, 25 items were finally remained within their original five factors. This shortened version of 25 items was called C-CLES25 to differentiate it from the original C-CLES30. Reliability, exploratory and confirmatory factor analyses were re-conducted to assess its factor structure.

Firstly, the 25 items were subjected to an exploratory factor analysis constrained by five factors (Table 2). The number of factors extracted should account for 50–60% of the variance in the items and, for any factor to be meaningful, at least 5% of the total variance explained should be attributed to that factor (Hair, Black, Babin, and Anderson 2010). Five factors emerged with eigenvalues greater than 1. The five-factor model by PCA with varimax rotation accounted for 61.86% of the total variance, a higher amount than the 56.51% for C-CLES30. All items loaded strongly on their hypothesised scale except that Item 14 (Critical Voice) loaded more strongly on Shared Control (0.38) than on its hypothesised Critical Voice scale (0.29).

Secondly, a confirmatory factor analysis on 967 cases was conducted to further evaluate the relative fit of the five-factor models with 25 items. Model fit was improved significantly. As shown in Table 3, the fit indices for the model of C-CLES25 were χ^2 (265) = 1406.02, $p < 0.001$; CFI = 0.90; NFI = 0.88; RMSEA = 0.07, indicating that the hypothesised model had a good fit to the data. The standardised path coefficients were all significant and varied from 0.27 to 0.89.

To further determinate whether the two versions (C-CLES30 and C-CLES25) exhibit essentially the same coherence, correlations among scales of these two versions were investigated (Table 4). Correlations among the five factors of C-CLES25 ranged from 0.07 to 0.41. Although the correlation between Shared Control and Uncertainty decreased from 0.11 to 0.07, most of the inter-correlations between scales of C-CLES25 remained similar or increased, such as the correlations between Personal Relevance and Critical Voice increasing from 0.28 to 0.41, and between Student Negotiation and Critical Voice increasing from 0.32 to 0.43.

Thirdly, overall internal consistency of the C-CLES25 was very good (Cronbach alpha = 0.89) and similar to that of the C-CLES30 (Table 5). The Cronbach alphas for the five scales varied from 0.67 to 0.93 (0.77 for Personal Relevance, 0.73 for Uncertainty, 0.67 for Critical Voice, 0.93 for Shared Control and 0.88 for Student Negotiation). Compared with the C-CLES30, the alphas for the five scales of C-CLES25 were similar except for Critical Voice (from 0.75 to 0.67). Indeed, this is plausible because the reliability tends to increase as the number of items increases. The internal consistency of 3-item Critical Voice scale could be considered adequate with values around 0.70 (Kline 2015).

Criterion-related validity

Students' cognitive strategies and academic ability were assumed to be criterion constructs suitable for checking the concurrent validity of students' perceptions of constructivist learning environment. Cognitive strategies were measured by two scales of MSLQ and one item of self-report. The Liberal Studies score on the school examination was used as a measure of ability.

Table 2 Rotated factor matrix for C-CLES (25-item model) based on exploratory factor analyses constrained to five factors

Item	Item wording	Factor loadings				
		1	2	3	4	5
22	I help the teacher to decide how much time I spend on learning activities	0.86				
23	I help the teacher to decide which activities I do	0.86				
20	I help the teacher to decide how well I am learning	0.85				
21	I help the teacher to decide which activities are best for me	0.85				
19	I help the teacher to plan what I'm going to learn	0.80				
24	I help the teacher to assess my learning	0.80				
29	Other students ask me to explain my ideas		0.78			
30	Other students explain their ideas to me		0.78			
27	I explain my understandings to other students		0.78			
28	I ask other students to explain their thoughts		0.77			
26	I talk with other students about how to solve problems		0.74			
25	I get the chance to discuss with other students		0.67			
1	I learn about the world outside of school			0.75		
4	I get a better understanding of the world outside of school			0.74		
5	I learn interesting things about the world outside of school			0.71		
2	My new learning starts with problems about the world outside of school			0.70		
3	I learn how this subject can be part of my out-of-school life			0.50		
9	I learn that this subject is influenced by people's values and opinions				0.74	
8	I learn that this subject has changed over time				0.74	
10	I learn about different knowledge of this subject used by people in other cultures				0.71	
7	I learn that this subject cannot provide perfect answers to problems				0.65	
11	I learn that this subject is different from that of long ago				0.56	
17	It's OK for me to express my opinion					0.84
18	It's OK for me to speak up for my rights					0.84

Table 2 (continued)

Item	Item wording	Factor loadings				
		1	2	3	4	5
14	It's OK for me to question the way I'm being taught	0.38				0.29
	Eigenvalue	7.11	3.41	2.00	1.74	1.20
	Percentage of variance	18.58	15.16	10.65	10.01	7.46
	Cumulative percentage of variance	18.58	33.73	44.39	54.40	61.86

Items with loadings less than 0.30 were eliminated except for Item 55

Table 3 Goodness-of-fit statistics for the C-CLES30 and C-CLES25

Model	x^2	df	NFI	CFI	RMSEA	Alpha
30-item	3505.09*	395	0.75	0.77	0.09	0.89
25-item	1406.02*	265	0.88	0.90	0.07	0.89

NFI Normed Fit Index, *CFI* Comparative Fit Index, *RMSEA* Root Mean Square Error of Approximation

* $p < 0.001$

Table 4 Intercorrelations between scales based on 30-item version (above diagonal) and 25-item version (below diagonal) of C-CLES

Scale	Correlations				
	PR	UN	CV	SC	SN
Personal Relevance		0.32***	0.28***	0.21***	0.37***
Uncertainty	0.32***		0.26***	0.11**	0.30***
Critical Voice	0.41***	0.24***		0.36***	0.32***
Shared Control	0.23***	0.07*	0.35***		0.34***
Student Negotiation	0.38***	0.29***	0.43***	0.34***	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 5 Number of items and alpha reliability coefficients for various scales of two versions of CLES

Scale	C-CLES30		C-CLES25	
	Items	Alpha	Items	Alpha
Overall instrument	30	0.89	25	0.89
Personal Relevance	6	0.72	5	0.77
Uncertainty	6	0.72	5	0.73
Critical Voice	6	0.75	3	0.67
Shared Control	6	0.93	6	0.93
Student Negotiation	6	0.88	6	0.88

Table 6b shows the correlations between the C-CLES25 scales, cognitive strategies (elaboration and metacognitive self-regulation) and academic ability. As predicted, significant and positive correlations were found between the C-CLES25 total score and the scores of its five dimensions with elaboration, metacognitive self-regulation and academic ability in Liberal Studies. Correlations ranged from 0.09 to 0.57, with the exception of the correlation between Shared Control scale and academic ability ($r = 0.06$, $p > 0.05$). In particular, the correlations of both total C-CLES25 and Critical Voice scale with other variables were greater than those with C-CLES30. Correlations between total and elaboration, metacognitive self-regulation and academic ability were changed from 0.55 to 0.57, 0.50 to 0.52, and 0.20 to 0.21 respectively, while correlations between Critical Voice and elaboration, metacognitive self-regulation, and academic ability increased from 0.34 to 0.45, 0.28 to 0.38, and 0.13 to 0.21, respectively. These findings suggest that deletion of three items with low loadings improves the construct validity.

Table 6 Correlations between cognitive strategies, academic ability and C-CLES30 scales using 30-item model (a) and C-CLES25 scale using 25-item model (b)

Strategy/ability	Correlations					
	PR	UN	CV	SC	SN	Total
(a)						
Elaboration	0.47***	0.24***	0.34***	0.36***	0.42***	0.55***
Metacognitive self-regulation	0.45***	0.21***	0.28***	0.34***	0.39***	0.50***
Academic Ability	0.25***	0.09**	0.13***	0.06	0.15***	0.20***
(b)						
Elaboration	0.48***	0.21***	0.45***	0.36***	0.42***	0.57***
Metacognitive self-regulation	0.45***	0.18***	0.38***	0.34***	0.39***	0.52***
Academic Ability	0.24***	0.09**	0.21**	0.06	0.15**	0.21***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

In short, the study indicated that scores on the C-CLES25 in this research had criterion-related validity.

Discussion and conclusion

This study focused on the psychometric properties of a Chinese version of Constructivist Learning Environment Survey (C-CLES30). Both exploratory and confirmatory factor analysis indicated a five-factor structure with 25 items (C-CLES25) rather than the 30 items (C-CLES30) proposed by Taylor et al. (1997) and translated into Chinese by Aldridge et al. (2000). The scales are Personal Relevance (5 items), Uncertainty (5 items), Critical Voice (3 items), Shared Control (6 items) and Student Negations (6 items). The total amount of variance accounted for by the 25 items in the five scales was 61.86%, suggesting a relatively similar or higher percentage than reported in previous researches (e.g., 60.1% and 60.6% by 29 items in Taiwan and Australia by Aldridge et al. 2000; 53.8% by 25 items in Malaysia by Wong et al. 2010; and 40.6–45.5% by 26 items in US by Nix et al. 2005). The goodness-of-fit indices suggested fit to the data, indicating theoretical and empirical consistency. Therefore, the C-CLES25 demonstrated good internal consistency with the sample of secondary-school students of this study.

Furthermore, a moderate level of criterion-related validity was found for the C-CLES25 and its scales. Scores on the scales were significantly related to the measures as predicted. In particular, the correlations of Critical Voice with other measures were stronger using C-CLES25 than C-CLES30. Dimensions of constructivist learning environment were associated with cognitive strategies (elaboration and metacognitive self-regulation) and academic ability as demonstrated in previous research (e.g., Galand et al. 2003; Lee and Fraser 2000). The five dimensions of constructivist learning environment all positively related to cognitive strategies and academic ability except between Shared Control and academic ability. This finding is reasonable because Shared Control assesses the extent to which students are invited to share control with the teacher over the learning and assessment activities. Because this 'collaborative' mode might be more time-consuming than teacher-dominant delivery of subject content, it was not related to students' academic performance in their school examination.

A comprehensive examination involving exploratory and confirmatory factor analyses, reliability and criterion validity suggested that C-CLES25 is psychometrically-sound for secondary school-students, making it one of the few available instruments that measure constructivist characteristics in classrooms. In terms of instrument validation, this study adds further information to the psychometric properties of the C-CLES30 and CLES25, including their factor structure, reliability and validity. The 30-item model of the instrument obtained from the exploratory and confirmatory factor analyses did not show all items strongly loading on their hypothesised scale but, with the deletion of five items with low loadings, factor analyses supported the five dimensions with 25 items of the C-CLES25. In addition, the findings provided support for the factor structure using confirmatory factor analysis and criterion-related validity for the C-CLES and its scales, filling a research gap in the previous literature.

Although the present study adds further evidence to the literature on the psychometric properties of the C-CLES25, there were several limitations. First, because the study employed a convenience sample which might cause selection bias, the generalisability of the findings to other population beyond secondary school students could be affected. Secondly, although the present study replicates research findings on the psychometric properties of the C-CLES25, there is a need to further investigate its concurrent and predictive validity by checking how its scores are related to other constructs, such as cognitive and motivational outcomes. In particular, the discriminate validity was not tested in this study. Thirdly, because the study assessed only the perceived constructivist learning environment of secondar- school students, perceptions from different samples of teachers and primary-school students should be collected. This would enable comparison of their differences in perspectives and checking of the consistency of C-CLES25 across different samples.

The present study has contributed to the literature by adding knowledge of the psychometric properties of the C-CLES30, thereby filling a research gap concerning psychometric properties of the CLES and the influences of measurement errors. After deleting fives items with low factor loadings from Personal Relevance, Uncertainty and Critical Voice, this study supported the psychometric properties of factor structure, reliability and validity for the C-CLES25. Methodologically, the study demonstrated the potential value of exploratory and confirmatory factor analyses and item-total correlations for examining the dimensionality of the C-CLES30 and C-CLES25, and therefore suggested a comprehensive validation of an instrument. In addition, the evidence of criterion-related validity in term of concurrent validity of the C-CLES25 was established by demonstrating moderate associations between dimensions of the constructivist learning environment and cognitive strategies (elaboration and metacognitive self-regulation) and academic ability. The sound psychometric properties of the C-CLES25 suggests that the instrument could be used as a tool for understanding how students perceive their learning environment in terms of constructivist characteristics. Finally, this study will help educators and researchers to select an appropriate instrument to measure the extent of constructivist learning environments in classrooms and their effects on learning. This is essential because fostering students to learn and think by creating constructivist learning environment is one of main curriculum guidelines under the education reform in Hong Kong. An instrument with sound psychometric properties could enhance the credibility of findings.

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