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Conceptualisation, measurement and preliminary validation of learners' problem-based learning and peer assessment strategies in a technology-enabled context

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This study attempted to conceptualise and measure learners' perceptions of their collaborative problem-based learning and peer assessment strategies in a technology-enabled context. Drawing on the extant literature, we integrate collaborative, problem-based and peer assessment learning strategies and propose a new model, the collaborative problem-based learning and peer assessment (Co-PBLa-PA) conceptual framework, which forms the basis of a new psychometrically sound and conceptually based scale, the collaborative problem-based learning and peer assessment strategies inventory (CO-PBLa-PA-SI). The development and validation of the CO-PBLa-PA-SI, based on the methodological and conceptual insights gained from prior research, involved identifying the following four scales: capacity to collaborate, readiness to engage, task-based interest and peer feedback usefulness. An item pool comprising of 16 items was established and verified by two panels of judges using a formalised card sorting procedure. Confirmatory factor analysis was conducted to validate the instrument of a small-scale (N = 164) study. The CO-PBLa-PA-SI scale showed strong construct validity and reliability with a Cronbach's coefficient alpha ranging from .828 to .880, which suggested strong internal consistency. The resultant instrument is intended as a tool to reliably measure learners' perceptions of their collaborative problem-based learning and peer assessment strategies in a technology-enabled context.

Implications for practice or policy:

- A psychometrically validated scale could be used by a growing community of academicians, educators and instructional designers to assess learners' collaborative problem-based learning and peer assessment strategies when using interactive technologies;
- A systematically collected data set obtained from the CO-PBLa-PA-SI data may have practical implications in terms of informing teachers about appropriate instructional design practices for the enhancement of collaborative, problem-based and peer assessment learning strategies in technology-enabled settings.

Keywords: collaborative problem-based learning, peer assessment, technology-enabled, capacity to collaborate, readiness to engage, task-based interest, peer feedback usefulness

Introduction

New methodologies in pedagogical practice and technology-based instruction support interaction techniques that engage learners in learning activities that emphasise active problem-based instructional methods, thereby supporting their intellectual capabilities and higher-order and deep learning-based approaches to learning (Sugeng & Suryani, 2020). Consequently, few instructors are aware of how these technologies are reshaping learners' motivational goals, learning abilities and interactions. Collaborative and problem-based learning approaches, for example, have received significant scholarly attention recently, in terms of instructional design, pedagogical approach and educational technology contexts (Hafeez, 2021; Tâm, 2021). Such approaches are increasingly employed to develop higher-level critical thinking, interactive and collaborative problem-solving skills (Unal & Cakir, 2021). Moreover, a peer assessment approach allows learners to make assessments of others within a collaborative social interactional process (Alt & Raichel, 2020).

However, these technology-based active learning approaches have not been conceptually, theoretically or empirically integrated in a way that transforms learning environments into digitally rich learner-centred, problem-based active spaces that support both higher-order cognition and affective components of collaborative, problem-based and peer-assessed learning strategies. The increasing use of digital technologies makes it critical to expand research of such strategies within technology-enabled contexts. Emerging technologies such as interactive online whiteboards (IOWBs) have proven to be successful in supporting active learning (Ng et al., 2020), helping to expand and shape critical thinking, problem-solving and analytical reasoning skills, while engaging learners in information sharing, social learning and peer assessment (Adel & Abdelrahman, 2019). Therefore, an understanding of learners' perceptions of their collaborative problem-based learning and peer assessment strategies, in a technology-enabled context, plays a pivotal role in supporting and enhancing student learning. This study focuses on these strategies implemented using IOWBs as the collaborative medium, which fulfills all the requirements for implementing the targeted pedagogies.

Background and literature review

This review formed the basis of the collaborative problem-based learning and peer assessment (Co-PBLa-PA) conceptual framework, which lay the groundwork for the development and validation of the collaborative problem-based learning and peer assessment strategies inventory (CO-PBLa-PA-SI) instrument. It also motivated the rationale for this study, highlighting how research on learners' perceptions of such strategies is essential in order to understand the complex set of variables associated with academic performance and motivational outcomes.

Various studies have been conducted on collaborative, problem-based and peer assessment learning strategies in teaching and learning (Alt & Raichel, 2020; Stančić, 2021; Unal & Cakir, 2021). However, studies on the systematic integration of these three pedagogies, within a technology-enabled context, have not been adequately explored or discussed in a distinct and clear-cut manner. Hence, existing studies are fragmented and scattered, creating a void in both literature and practice. This literature review synthesises, analyses and integrates relevant literature regarding collaborative learning strategies,) problem-based learning strategies and peer assessment strategies and proposes a conceptual framework by identifying underlying theories and applications. Moreover, relevant studies provided a detailed understanding and insight into the impact of such strategies on learner performance. With the potential positive impact on student learning, this study attempts to bridge the empirical-theoretical research gap by providing a conceptually grounded definition of Co-PBLa-PA. This definition, derived from a critical systematic research review, guides the conceptual framework and directs the following instrument development and validation process.

Technology-enabled learning contexts

The utilisation and delivery of digital learning technologies have become prevalent globally, with a clear effect on student engagement in addition to other aspects of the learning experience (Bedenlier et al., 2020; Ng et al., 2020). Furthermore, the COVID-19 pandemic required teachers to move to online mediums, increasing the use of educational technology and recognition of the importance of technology to prepare students for future employability. In the context of IOWBs, technology-enabled tools have the potential to change the mode by which learners interact and the means by which collaborative, problem-based and peer assessment learning strategies are conceptualised and used in teaching and learning activities (Bedenlier et al., 2020; Ng et al., 2020; Shi et al., 2021). Consequently, the effective integration of interactive technology with this learner-centred pedagogical approach enables learners to not only better reflect on their learning processes and outcomes but also facilitates them in subsequently developing their critical thinking, analytic and problem-solving skills, through ongoing and constructive feedback.

Collaborative learning strategies

The concept of collaborative learning has been widely researched in academic literature (Hendarwati et al., 2021; Nokes-Malach et al., 2015). Collaborative learning, both face-to-face and technology-enabled, is an extensively used approach in which learners interact purposefully together for learning activities in groups to complete distinct tasks and objectives (Ergulec, 2019; Meijer et al., 2020). Collaborative learning strategies are defined as the actions and systematic joint efforts (i.e., readiness to engage in learning activities) of learners working together to solve a problem and complete an activity or a sequence of learning activities (Nsor-Ambala, 2022). Prior studies have primarily focused on the application of collaborative learning and their positive effects on learner achievement, engagement, group performance and learning outcomes (Aslan, 2021; Kirschner et al., 2011; Panitz & Panitz, 1998; Zhu, 2012). Collaborative learning is considered central to group engagement, not only enhancing motivation and achievement but also increasing learning gains at both individual and group levels (Aslan, 2021; Xie et al., 2019).

From a socio-constructivist and learner-centred perspective, there is an emphasis on the role of social interaction and engagement among peers during collaborative activities (Unal & Cakir, 2021). By engaging in collaborative task-based activities, learners build on prior knowledge, share perspectives and apply knowledge and skills in relevant contexts to solve applied problems (Lai, 2021). Jonassen et al. (2005) highlighted the potential beneficial impact of applying collaborative learning to support higher-order thinking skills, active construction of knowledge and deeper learning (Koszalka et al., 2021; Lu et al., 2021). Moreover, readiness factors have been studied in the context of computer-supported collaborative learning, especially in terms of readiness to engage in online social interactions and in activities that challenge learners' perspectives and evoke a sense of interest and group involvement (Xiong et al., 2015).

Problem-based learning strategies

Problem-based learning strategies are theorised to be effective pedagogical approaches that support cognitive and constructivist learning theories with the intention of developing learners' abilities to work together in groups by interacting in tasks that have real-world relevance (Al-Hebaishi, 2018; Alt & Raichel, 2020). From a cognitive perspective, problem-based learning focuses on applying cognitive skills through problem-solving tasks and subsequently applying higher-order thinking processes, such as analytical and logical reasoning, abstract conceptualisation and synthesis (Lee & Choi, 2017). From a constructivist perspective, problem-based learning focuses on co-constructing meaning from pre-existing knowledge and then developing and applying new knowledge to solve specific problem-based learning tasks (Kwan & Wong, 2015). Within the context of technology-supported learning, collaborative and problem-based learning strategies are particularly effective in increasing students' online interactions, advancing conceptual understanding of the material and deepening problem-based inquiry and higher-order critical thinking skills (Lubis et al., 2019).

Peer assessment strategies

Peer assessment is fundamentally a social and collaborative learning process in which groups of individuals rate, mark and provide reciprocal feedback on the work of other individuals or groups (Adachi et al., 2018; J.-W. Lin et al., 2021). Aspects of peer assessment include contributing towards the completion of group tasks and purposeful participation in group discussions with active involvement in decision-making activities (Kollar & Fischer, 2010). Moreover, peer assessment allows learners to evaluate or be evaluated by their peers and subsequently "judge and make decisions about the work of their peers against particular criteria" (Adachi et al., 2018, p. 303). Consequently, online peer feedback is an important determinant of peer assessment within the field of technology-supported learning, allowing and emboldening learners to interact, review, evaluate, assess and comment on the work of their peers (Gielen & De Wever, 2012; Xiong et al., 2015).

Multiple strategy approaches

Despite numerous studies on the above strategies, research on implementing this combination of strategies is limited. Notably, literature that explores strategies that combine collaborative, problem-based and peer assessment learning typically targets assessment of individual performance within the structure of group work and is focused on an individual's ability in contributing to the group discussion (Babo et al., 2021; Roberts et al., 2017). On assessing a whole group's perfomance, findings are sparse. One such study, by Kritikos et al. (2011) on intergroup peer assessment outside of a technology-enabled context, yielded positive results in student perception and an appropriate assessment tool within problem-based learning.

Furthermore, with the rising shift and prevalence of online classes as well as increased availability of devices in classes, it is suitable to explore these pedagogies in a technology-enabled context. As evidenced by the positive results of Ng et al.'s (2020) Co-PBLa-PA study, technology-enabled active learning pedagogies are a promising direction in this limitedly explored area. According to the interactive, constructive, active and passive framework proposed by Chi and Wylie (2014), the integration of the Co-PBLa-PA approach allows for active engagement in constructivist problem-based and inquiry-based learning strategies and higher-order cognitive processes such as critical thinking and logical reasoning. These promising, yet separate, results on the combination of collaborative, problem-based, peer assessment and technology-enabled learning indicate this as a worthwhile topic for further research and bridge the current gap in literature and practice.

Co-PBLa-PA approach

We propose an encompassing and conceptually grounded definition of Co-PBLa-PA, based on an extensive review of pertinent research studies (Aslan, 2021; Care et al., 2016; Hendarwati et al., 2021; Stančić, 2021). The definition appraises the conceptual underpinnings and model presented below and guides the instrument development process. Co-PBLa-PA is defined and operationalised as a learner-centred pedagogical approach in which learners are able to (a) integrate knowledge and skills by collaborating with peers in group-based learning tasks (i.e., capacity to collaborate); (b) interact and engage in problem-based anchored instruction whilst working in small groups to solve problems by asking questions, posing possible solutions and building consensus (i.e., readiness to engage); (c) participate in cognitively challenging problem-based learning tasks that elicit interest (i.e., task-based interest); and (d) review and assess each groups' efforts through peer grading and peer feedback to enhance group peer problem-based learning and assessment (i.e., peer feedback usefulness). This definition will be the basis of the conceptual framework, encapsulating the various common and individual aspects of each learning approach.

Conceptual framework

Figure 1 presents an illustration of the Co-PBLa-PA conceptual framework, devised by identifying the following four constructs – capacity to collaborate (CTC), readiness to engage (RTE), task-based interest (TBI) and peer feedback usefulness (PFU) – and lays out the conceptual and methodological basis of the subsequent stages of the instrument development and validation process. A conceptualisation of each construct is defined, described and exemplified, forming the foundation of the framework and associated measurement scales.

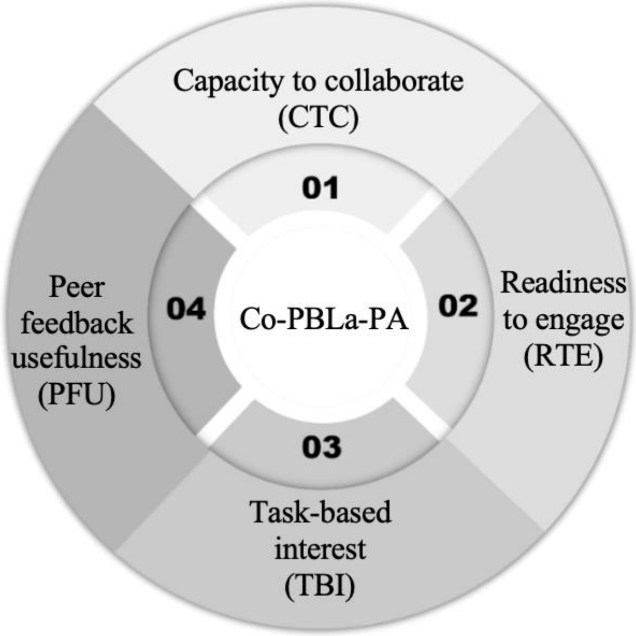

Figure 1. Co-PBLa-PA conceptual framework

Capacity to collaborate

Capacity to collaborate is defined as an individual learner's propensity to work together on a task through the joint construction of shared meaning and understanding by collectively coordinating activities towards a shared goal (Reeves & Reeves, 2012). The distinctive feature of collaboration is its emphasis on group coordination and shared understanding to achieve a common goal (Hämäläinen & Vähäsantanen, 2011), with each learner having the capacity to contribute. The underlying concept is that of collaborative inquiry and group problem-solving, in which learners co-construct meaning by integrating ideas and understanding through group-based activities (Baker, 2015; Saleh et al., 2020). Learners develop their individual understandings by generating their own connections, thereafter co-constructing new meaning and insights, synthesising multiple perspectives and elaborating on the views of others through collaborative discourse (Arvaja et al., 2007).

Readiness to engage

Readiness to engage is conceptualised by the individual's self-perception of feeling a sense of connectedness and involvement through group interactions (Beth et al., 2015; Xiong et al., 2015). It is the degree to which individuals are prepared to actively undertake and engage in tasks and/or activities by sharing knowledge, exploring ideas, clarifying meanings, supporting multiple perspectives and reaching group consensus (Xiong et al., 2015). Moreover, it refers to the extent to which the learner is able to connect to what, how and with whom they learn, suggesting a willingness to participate actively and persistently (Fisher & King, 2010; Handley et al., 2011). Furthermore, readiness to engage is an internal state of psychological inclination to interact and engage in problem-based instruction (W. Lin & Chapman, 2020). Hence, such engagement approaches emphasise problem-solving in the context of specific learner characteristics and motivation (Krapp, 1999).

Task-based interest

Task-based interest is described as an individual's desire to participate in cognitively challenging problem-based tasks that capture interest (Chin & Wang, 2021; Schraw & Lehman, 2001). It is the degree to which the task or activity captures the individual's attention, expending more effort and time and, finally, processing the information at a deeper level (Schiefele, 1991). Hence, the learner is driven by a sense of interest and curiosity with an intrinsic desire to succeed in more difficult and optimally challenging tasks. Moreover, task-based interest is a motivational variable characterised by focused attention and positive affective involvement – this suggests that the more interest learners exhibit, the more they are motivated and committed to the learning experience. According to Hidi and Renninger (2006), interest refers to the appealing effect of characteristics in an activity that triggers the intrinsic desire to seek out, acquire and construct new knowledge through a process of discovery and exploratory investigation, intrinsically motivating a drive to master challenging tasks (Shroff et al., 2021).

Peer feedback usefulness

Peer feedback is an instructional approach in which learners evaluate the performance of their peers by providing constructive comments and evaluative feedback on their peers' work (Quinlan & Pitt, 2021). The usefulness aspect refers to learners' subjective assessment, expectancy and perceived positive benefits of peer feedback (Van der Kleij & Lipnevich, 2021). Hence, peer feedback usefulness refers to learners' perceptions of the benefits or value of activities and subsequently, sharing their work with peers for reciprocal comments and inputs. Peer feedback also allows learners to develop, share and discuss multiple perspectives by comparing peers' work to their own (Cheah & Li, 2020; Henderson et al., 2019). Furthermore, peer feedback allows learners to review and assess each group's efforts through reflective dialogue and discussion of the work of others, including peer grading, peer review and peer assessment (Van der Pol et al., 2008).

Research methodology

Based on this conceptual framework, we present the instrument development process of the CO-PBLa-PA-SI. To develop a valid and reliable self-reported measure of learners' perceptions, we followed an instrument development procedure based on the method proposed by Moore and Benbasat (1991), comprised of the following three methodological steps: (1) item creation, (2) card sorting and (3) instrument testing.

Item creation

Item creation was based on a procedure comprising of item generation, item editing and item reduction, to establish content validity of the items and optimise the psychometric properties of the instruments, ensuring items adequately reflected the construct definitions in the Co-PBLa-PA framework. Firstly, we generated and developed an item pool based on a conceptual analysis and review of extant literature. Items were conceptually driven based on conceptual foundations and research underpinnings derived from literature on learner motivation including cognitive, affective and behavioural components, as well as conceptual definitions of collaborative, problem-based learning and peer assessment. Secondly, to derive an optimal set of representative items, the item pool was refined, and any ambiguous, inconsistently understood or problematic items were deleted or re-edited to ensure clarity and comprehension.

Card sorting

Following Moore and Benbasat's (1991) process, two sorting rounds were conducted: first exploratory, then confirmatory. Four judges arranged the items into construct categories by ranking how well the items fit in their respective construct definitions. In the first sorting round, the labels of the underlying constructs were undisclosed – instead, the judges provided their own labels and definitions. In the second round, the judges sorted the items into four given construct definitions. Confidence in the construct validity increased if the judges' definitions matched the scale's intent.

Two different measurements were used to assess the reliability of the sorting. First, we measured the level of agreement in categorising all 16 items across all four judges using Cohen's kappa (Maxwell, 1970). In the first round, the kappa scores averaged 0.84. The value of 0.91 in the second round was higher, indicating an excellent fit based on the guidelines of Landis and Koch (1977) for interpreting the kappa coefficient. A second measurement was an item placement ratio, which measured the overall frequency with which the judges placed items within the intended target theoretical constructs. Hence, four theoretical constructs each comprising of 4 items were developed. With a panel of four judges, a theoretical maximum of 64 placements could be made (i.e., 4 constructs at 16 placements). A matrix of item placements is shown below, including an N/A (not applicable) column where judges placed items which they felt fit none of the categories.

Table 1
Matrix of item placements – first round

	Capacity to collaborate (CTC)	Readiness to engage (RTE)	Task-based interest (TBI)	Peer feedback usefulness (PFU)	N/A	Total	% hits
CTC	**12**	3	0	0	1	16	75%
RTE	2	**13**	0	0	1	16	81%
TBI	0	0	**14**	1	1	16	87.5%
PFU	0	1	1	**14**	0	16	87.5%

Note. Item placements: 64; hits: 53; overall hit ratio: 82.75%.

By examining the diagonal matrix (Table 1) a total of 53 hits was attained out of 64 placements, demonstrating an overall placement hit ratio of 82.75%. Items that were off-diagonal (i.e., tapped a non-intended construct) were identified and any inappropriately worded or ambiguous items were rephrased. The revised items were subjected to a second round with a new set of four judges for further clarification (Table 2).

Table 2
Matrix of item placements – second round

	Capacity to collaborate (CTC)	Readiness to engage (RTE)	Task-based interest (TBI)	Peer feedback usefulness (PFU)	N/A	Total	% hits
CTC	**15**	0	0	0	1	16	93.7%
RTE	0	**16**	0	0	0	16	100%
TBI	0	0	**15**	1	0	16	93.7%
PFU	0	0	0	**16**	0	16	100%

Note. Item placements: 64; hits: 62; overall hit ratio: 96.85%.

The resulting item placement displayed a higher agreement compared to the first round, indicating a significant improvement in matching accuracy. All constructs obtained a high item placement ratio with an overall hit rate of 96.85%, indicating a high degree of construct validity (Moore & Benbasat, 1991).

Instrument testing

The research setting
The study comprised of an adequate pool of 164 (N = 164) first-year undergraduate students enrolled in a Statistics for Business course at the Hong Kong Polytechnic University. The course provides students with basic techniques towards understanding and interpreting data and analysing business scenarios in commerce and industry by applying statistical techniques to real-world problems. The students were considered an appropriate fit within the scope of the study's intended focus and objective. The course was selected since it provided context to incorporate the Co-PBLa-PA instructional approach using IOWBs in the instructional design and lesson delivery. The IOWB selected was Conceptboard (https://conceptboard.com/). With their personal digital devices, users can interact simultaneously on a whiteboard canvas by integrating text with visual objects (i.e., drawings, images and Post-it notes).

Co-PBLa-PA instructional approach

Seven 60-minute tutorial sessions, conducted over a 4-week period by the same instructor in topics including descriptive statistics, probability and probability distributions, were structured according to the Co-PBLa-PA approach as implemented and introduced by Ng et al. (2020). The following procedure encompasses all four aspects of the Co-PBLa-PA framework through its group-based and problem-based structure and use of an IOWB (Figure 2).

(1) Students were provided instruction with examples for relevant statistical concepts and procedures.
(2) Students were divided into 10 groups, with 5–10 students per group. Each group was tasked with solving a pre-designed problem on their designated section on Conceptboard.
(3) Each group was assigned another group's work to mark.
(4) Each group was tasked with providing comments on their own peer-marked work.
(5) The instructor clarified misconceptions or confusion, highlighted key points and summarised the main concepts.

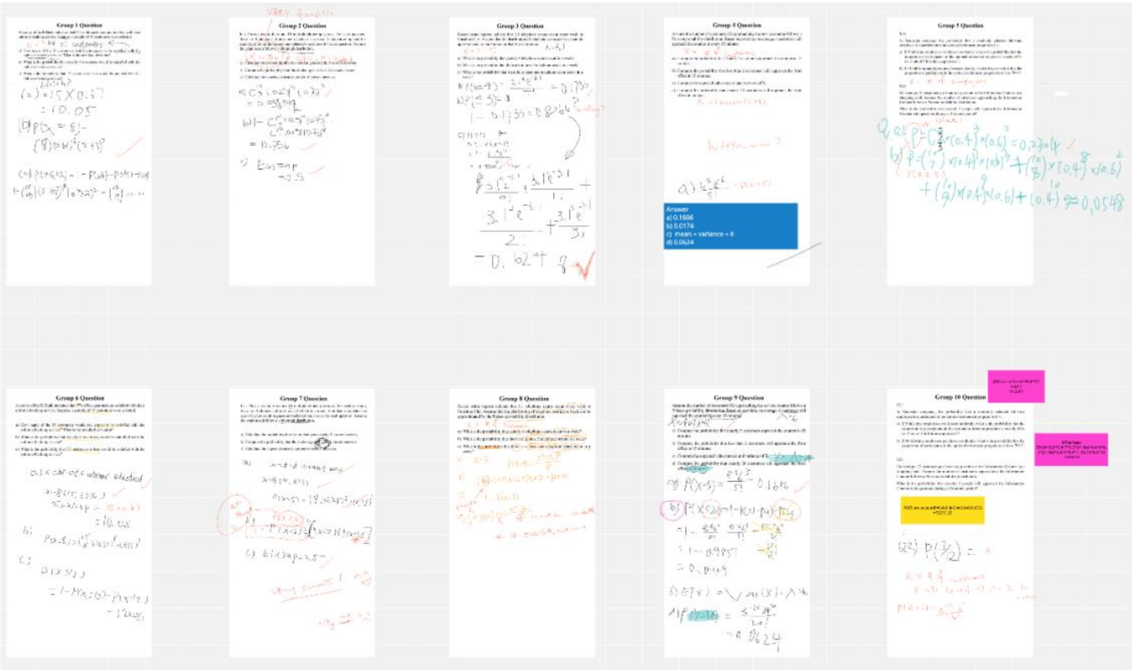

Figure 2. Example of IOWBs from a tutorial session

Measurement scales

The finalised instrument comprised two sections. Section I identified the demographic traits of the respondents. Section II was constructed from the Co-PBLa-PA framework. Our research model comprised 16 items (Table 6) that measured capacity to collaborate (4 items), readiness to engage (4 items), task-based interest (4 items) and peer feedback usefulness (4 items). The response for all items was a 7-point positively packed Likert scale (Lam & Klockars, 1982) coded from 7: *strongly agree* to 1: *strongly disagree* (with midpoint 4 being *neither agree nor disagree*). The range of possible scores was 16–112 points, with higher scores indicating more positive perceptions. To avoid bias and confusion, no negative statements were included.

Data collection

The CO-PBLa-PA-SI (Appendix) was distributed to 178 students, online with randomised item order item order during the last week of Semester 1 of 2020. It yielded 164 usable responses, providing a response rate of 92%. With a sample size of 164, a power test indicated a power of 81% to yield a statistically significant result and mean difference with a confidence level of 95%, (α level = 0.05; power = 0.95)

(Cohen, 1992). Ethical clearance for the study was granted from the ethical review board of the institution, and all the procedures were executed with informed consent from participants prior to commencement and in accordance with the institution's guidelines and requirements on ethical standards.

Results and analyses

Descriptive statistics

Descriptive statistics of the four constructs were computed (Table 3), with all means above the midpoint of 4.00 and the standard deviations ranging from .93 to 1.20, indicating a narrow spread of item scores.

Table 3
Summary of means and standard deviations (N = 164)

Constructs	Question	Mean	Standard deviation
CTC	1	5.201	1.173
	5	4.957	1.215
	9	5.152	1.060
	13	5.006	1.180
RED	2	5.006	1.180
	6	5.146	1.126
	10	5.061	1.066
	14	5.061	1.128
TBI	3	5.073	1.048
	7	5.183	1.041
	11	5.012	1.091
	15	4.921	1.124
PFU	4	5.049	1.217
	8	5.000	1.183
	12	5.012	1.198
	16	5.061	1.123

Construct validity

Confirmatory factor analysis was performed to examine factor structure, item loadings and model fit of the instrument (Table 4). No items were removed from the scale due to loading on two factors or having low factor loadings based on the results of the factor analysis. The results yielded statistically significant and relatively moderately high factor loadings ranging from .70 to .85, demonstrating that all items were reliable indicators of the construct, yielding solid factor structure and adequate psychometric properties.

Table 4
Constructs, items and loading statistics

Question	Constructs	Items	Factor loading
		Capacity to collaborate (CTC)	
1	CTC1	I felt the activity allowed me to effectively work together on a task.	0.76
5	CTC2	I am more predisposed to exploring ideas by working together in a group than on my own.	0.85
9	CTC3	I felt working together in a group deepened my understanding of the topic.	0.81
13	CTC4	I am more apt to work together in a group by taking into account different points of views of others.	0.84
		Readiness to engage (RED)	
2	RED1	I was eager to engage in thought-provoking tasks that elicit deeper levels of thought.	0.76
6	RED2	I felt a sense of willingness to take part in problem-solving tasks by actively sharing knowledge.	0.70
10	RED3	I was able to effectively interact by contributing information from multiple viewpoints.	0.73
14	RED4	I felt the activity allowed me to effectively interact in an open exchange of ideas.	0.76
		Task-based interest (TBI)	
3	TBI1	I felt the activity aroused my curiosity by prompting me to probe further.	0.84
7	TBI2	I was committed to achieving the goals of the task by expending more effort.	0.77
11	TBI3	I was willing to exert effort by persisting at tasks I found challenging.	0.75
15	TBI4	I found the task elicited a sense of appeal.	0.78
		Peer feedback usefulness (PFU)	
4	PFU1	I found it positively beneficial to share work with other group members for constructive feedback.	0.79
8	PFU2	I was favourably inclined towards receiving prompt feedback from group members.	0.77
12	PFU3	I found merit in taking into account group members' evaluations of each group's solutions to the task.	0.82
16	PFU4	I felt the activity allowed me to realise the usefulness of group feedback in supporting my learning with peers.	0.83

Factor analysis showed that four factors accounted for 76.98% of the total variation. The first factor, CTC, accounted for 27.06% of the variation, while RED accounted for 21.18%, TBI accounted for 15.95% and PFU accounted for 12.82%. Moreover, the 16 items loaded onto four factors with eigenvalues greater than 1, suggesting that this 4-factor model represented the best data fit. Internal consistency reliability of each factor was assessed using Cronbach's (1955) alpha coefficient (Table 5). These scores ranged from 0.828 to 0.880, thereby exceeding the reliability estimates ($\alpha = 0.70$) recommended by Nunnally (1967). Hence, the resulting 16-item CO-PBLa-PA-SI scale demonstrated high internal consistency and reliability across all factors, indicating that individual scale items were measuring the same underlying construct.

Table 5
Cronbach's alpha reliability coefficient

Construct	Items	Alpha
CTC	4	0.883
RED	4	0.828
TBI	4	0.868
PFU	4	0.880

Convergent and discriminant validity

Convergent and discriminant validity of the measurement model was assessed and verified by the average variance extracted (AVE). The AVE of the constructs ranged from 0.74 to 0.81, exceeding the recommended threshold of 0.70 or higher for all constructs, thereby exhibiting a high degree of convergent validity (Table 6) (Hair et al., 2010). Using the Fornell and Larcker (1981) criteria to assess discriminant validity, the amount of variance tested by the construct and the shared variance with other constructs were comparatively evaluated. Table 6 indicates the comparison between the value of the square root of the AVE (diagonal elements from 0.742 to 0.812) of each construct and the correlation of the construct (0.772 to 0.860) with all other constructs (off-diagonal), thereby demonstrating marginal discriminant validity. To this end, the scales exhibited adequate convergent validity and marginally acceptable discriminant validity.

Table 6
Convergent and discriminant validity

Construct	CTC	RED	TBI	PFU
CTC	**.8129**			
RED	.8440	**.7420**		
TBI	.7720	.8490	**.7918**	
PFU	.8600	.8600	.7840	**.8070**

Note. Diagonal values are the square roots of the AVE. Off-diagonal values are the correlations between constructs.

Several goodness-of-fit measures (GFI) were computed (Table 7) to verify whether the proposed model exhibited an acceptable parsimonious fit (Bentler & Bonett, 1980). The first measure, the likelihood ratio chi-square statistic ($\chi 2$ (N = 164) = 294, $p < 0.01$), yields an acceptable fit. Based on the values proposed by Gefen et al. (2000) and Hair et al. (1998), GFI, comparative fit index (CFI) and normed fit index (NFI) are best if above 0.90 and demonstrate marginally acceptable fit if above 0.80, with an adjusted goodness-of-fit index (AGFI) above 0.80 and root-mean-square residual (RMR) below 0.05. Overall, the various GFI indices (GFI = .819, CFI = .906, AGFI = .749 and NFI = .867) revealed a modest fit with the data collected, despite a high root-mean-square error of approximation (RMSEA = .111), which could be a possible consequence of a small degrees of freedom and sample size. Thus, it is appropriate to avoid relying on RMSEA and caution is required when interpreting this value (Kenny et al., 2015).

Table 7
GFI measures

Fit measures	Values
$\chi 2$	294.165
RMR	.062
RMSEA	.111
GFI	.819
CFI	.906
AGFI	.749
NFI	.867

Note. CFI, cut-off > .90

Discussion, limitations and future directions

In this study, a Co-PBLa-PA conceptual framework was developed with a self-reported instrument, the CO-PBLa-PA-SI scale, with four constructs based on theoretical and conceptual work to cover the pertinent pedagogical aspects of learner's perception within these strategies. Following the instrument development process by Moore and Benbasat (1991) and assessing construct validity through confirmatory factor analysis and Cronbach's (1955) alpha, results indicated high internal consistency, reliability and construct validity, with Cronbach's alpha ranging from 0.82 to 0.88. Overall, the GFI indices fell within the range of the recommended value of 0.90 by Bentler and Bonnett (1980). In summary, the results indicate the CO-PBLa-PA-SI exhibited sound psychometric properties for measuring learners' perceptions of their collaborative problem-based learning and peer assessment strategies in a technology-enabled context.

To guide future research, we acknowledge several limitations when interpreting our results. Foremost, the relatively small and homogenous sample size may limit the generalisability of the results, and therefore, caution needs to be undertaken when extrapolating to different populations, settings and contexts. Furthermore, the self-reporting nature of the questionnaire may not accurately reflect respondents' actual attitudes and behaviours. There could have been various situational, contextual or demographic factors (e.g., bias towards instructors) which may have influenced learners' subjective responses. Moreover, this study implemented the learning strategies specifically using IOWBs. While this method appropriately facilitated all the constructs, other digital tools can facilitate them and may affect the results of this instrument. Collectively, these limitations demonstrate the need for future studies that will further elucidate the theoretical and measurement underpinnings in the context of Co-PBLa-PA.

The establishment of a conceptual Co-PBLa-PA framework and the construction of the CO-PBLa-PA-SI as a reliable instrument provide significant implications for furthering research, especially towards applying novel pedagogical approaches with technology, or towards other disciplines or digital tools to explore this instrument in other settings. Studies can also supplement our analysis by addressing the currently observed marginal discriminant validity of our study. Further examples include investigating the moderating and interaction effects between the constructs on learner performance and achievement. To this end, research could be extended by examining the effect of the psychological construct of intrinsic motivation together with strategies utilising Co-PBLa-PA.

To conclude, this study is of potential significance because it emphasizes the need for appropriate instruments to assess learners' perceptions of Co-PBLa-PA. This is aptly important with the prevalence of technology entering learning spaces, requiring these technologies to be implemented effectively and pedagogically. Moreover, this study contributes to literature by applying a methodological and conceptual framework on Co-PBLa-PA and following a rigorous instrument development procedure to achieve adequate psychometric properties that reliably and validly assess the purported constructs, allowing a growing community of researchers and educators alike to conduct further studies. Finally, a systematically collected data set obtained from the CO-PBLa-PA-SI data may have practical implications in terms of informing teachers of the most appropriate instructional design practices for the enhancement of collaborative, problem-based and peer assessment learning strategies in technology-enabled settings.

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References

Adachi, C., Tai, J. H.-M., & Dawson, P. (2018). Academics' perceptions of the benefits and challenges of self and peer assessment in higher education. *Assessment & Evaluation in Higher Education*, *43*(2), 294–306. https://doi.org/10.1080/02602938.2017.1339775

Adel, M. A., & Abdelrahman, M. A. (2019). The effects of using an electronic interactive whiteboard in developing students attitude, cognitive motivation and academic achievement. *Journal of Education and Practice*, *10*(10), 124–129. https://doi.org/10.7176/jep%2F10-10-15

Al-Hebaishi, S. M. (2018). Using the flipped classroom model to enhance problem-based learning in a practicum course. *International Journal of Technology Enhanced Learning*, *10*(4), 329–344. https://doi.org/10.1504/IJTEL.2018.095143

Alt, D., & Raichel, N. (2020). Problem-based learning, self-and peer assessment in higher education: Towards advancing lifelong learning skills. *Research Papers in Education*, *37*(3), 370–394. https://doi.org/10.1080/02671522.2020.1849371

Arvaja, M., Salovaara, H., Häkkinen, P., & Järvelä, S. (2007). Combining individual and group-level perspectives for studying collaborative knowledge construction in context. *Learning and Instruction*, *17*(4), 448–459. https://doi.org/10.1016/j.learninstruc.2007.04.003

Aslan, A. (2021). Problem-based learning in live online classes: Learning achievement, problem-solving skill, communication skill, and interaction. *Computers & Education*, *171*, Article 104237. https://doi.org/10.1016/j.compedu.2021.104237

Babo, R., Rocha, J., Fitas, R., Suhonen, J., & Tukiainen, M. (2021). Self and peer e-assessment: A study on software usability. *International Journal of Information and Communication Technology Education*, *17*(3), 68–85. https://doi.org/10.4018/IJICTE.20210701.oa5

Baker, M. J. (2015). Collaboration in collaborative learning. *Interaction Studies*, *16*(3), 451–473. https://doi.org/10.1075/is.16.3.05bak

Bedenlier, S., Bond, M., Buntins, K., Zawacki-Richter, O., & Kerres, M. (2020). Facilitating student engagement through educational technology in higher education: A systematic review in the field of arts and humanities. *Australasian Journal of Educational Technology*, *36*(4), 126–150. https://doi.org/10.14742/ajet.5477

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*(3), 588–606. https://doi.org/10.1037/0033-2909.88.3.588

Beth, A. D., Jordan, M. E., Schallert, D. L., Reed, J. H., & Kim, M. (2015). Responsibility and generativity in online learning communities. *Interactive Learning Environments*, *23*(4), 471–484. https://doi.org/10.1080/10494820.2013.788035

Care, E., Scoular, C., & Griffin, P. (2016). Assessment of collaborative problem solving in education environments. *Applied Measurement in Education*, *29*(4), 250–264. https://doi.org/10.1080/08957347.2016.1209204

Cheah, S., & Li, S. (2020). The effect of structured feedback on performance: The role of attitude and perceived usefulness. *Sustainability*, *12*(5), Article 2101. https://doi.org/10.3390/su12052101

Chi, M. T., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, *49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Chin, K.-Y., & Wang, C.-S. (2021). Effects of augmented reality technology in a mobile touring system on university students' learning performance and interest. *Australasian Journal of Educational Technology*, *37*(1), 27–42. https://doi.org/10.14742/ajet.5841

Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science*, *1*(3), 98–101. https://doi.org/10.1111/1467-8721.ep10768783

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*(4), 281. https://doi.org/10.1037/h0040957

Ergulec, F. (2019). Instructional strategies for forming online collaborative teams. *International Journal on E-Learning*, *18*(4), 349–372. https://www.learntechlib.org/primary/p/207505/

Fisher, M. J., & King, J. (2010). The self-directed learning readiness scale for nursing education revisited: A confirmatory factor analysis. *Nurse Education Today*, *30*(1), 44–48. https://doi.org/10.1016/j.nedt.2009.05.020

Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research*, *18*(3), 382–388. https://doi.org/10.1177/002224378101800313

Gefen, D., Straub, D., & Boudreau, M.-C. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the Association for Information Systems*, *4*(7), 1–77. https://doi.org/10.17705/1CAIS.00407

Gielen, M., & De Wever, B. (2012). Peer assessment in a wiki: Product improvement, students' learning and perception regarding peer feedback. *Procedia – Social and Behavioral Sciences*, *69*, 585–594. https://doi.org/10.1016/j.sbspro.2012.11.450

Hafeez, M. (2021). Systematic review on modern learning approaches, critical thinking skills and students learning outcomes. *Indonesian Journal of Educational Research and Review*, *4*(1). https://doi.org/10.23887/ijerr.v4i1.33192

Hair, J. F., Anderson, R. E., Babin, B. J., & Black, W. C. (2010). *Multivariate data analysis: A global perspective*. Pearson.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis*. Prentice-Hall.

Hämäläinen, R., & Vähäsantanen, K. (2011). Theoretical and pedagogical perspectives on orchestrating creativity and collaborative learning. *Educational Research Review*, *6*(3), 169–184. https://doi.org/10.1016/j.edurev.2011.08.001

Handley, K., Price, M., & Millar, J. (2011). Beyond 'doing time': Investigating the concept of student engagement with feedback. *Oxford Review of Education*, *37*(4), 543–560. https://doi.org/10.1080/03054985.2011.604951

Hendarwati, E., Nurlaela, L., Bachri, B. S., & Sa'ida, N. (2021). Collaborative problem based learning integrated with online learning. *International Journal of Emerging Technologies in Learning*, *16*(13), 29–39. https://doi.org/10.3991/ijet.v16i13.24159

Henderson, M., Ryan, T., & Phillips, M. (2019). The challenges of feedback in higher education. *Assessment & Evaluation in Higher Education*, *44*(8), 1237–1252. https://doi.org/10.1080/02602938.2019.1599815

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4

Jonassen, D., Lee, C., Yang, C., & Laffey, J. (2005). The collaboration principle in multimedia learning. In R. E. Mayer (Eds.), *The Cambridge handbook of multimedia learning* (pp. 247–270). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.017

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociological Methods & Research*, *44*(3), 486–507. https://doi.org/10.1177/0049124114543236

Kirschner, F., Paas, F., Kirschner, P. A., & Janssen, J. (2011). Differential effects of problem-solving demands on individual and collaborative learning outcomes. *Learning and Instruction*, *21*(4), 587–599. https://doi.org/10.1016/j.learninstruc.2011.01.001

Kollar, I., & Fischer, F. (2010). Peer assessment as collaborative learning: A cognitive perspective. *Learning and Instruction*, *20*(4), 344–348. https://doi.org/10.1016/j.learninstruc.2009.08.005

Koszalka, T. A., Pavlov, Y., & Wu, Y. (2021). The informed use of pre-work activities in collaborative asynchronous online discussions: The exploration of idea exchange, content focus, and deep learning. *Computers & Education*, *161*, Article 104067. https://doi.org/10.1016/j.compedu.2020.104067

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education*, *14*(1), 23–40. https://doi.org/10.1007/BF03173109

Kritikos, V. S., Woulfe, J., Sukkar, M. B., & Saini, B. (2011). Intergroup peer assessment in problem-based learning tutorials for undergraduate pharmacy students. *American Journal of Pharmaceutical Education*, *75*(4), Article 73. https://doi.org/10.5688/ajpe75473

Kwan, Y. W., & Wong, A. F. (2015). Effects of the constructivist learning environment on students' critical thinking ability: Cognitive and motivational variables as mediators. *International Journal of Educational Research*, *70*, 68–79. https://doi.org/10.1016/j.ijer.2015.02.006

Lai, C. L. (2021). Effects of the group-regulation promotion approach on students' individual and collaborative learning performance, perceptions of regulation and regulation behaviours in project-based tasks. *British Journal of Educational Technology*, 1–21. https://doi.org/10.1111/bjet.13138
Lam, T. C., & Klockars, A. J. (1982). Anchor point effects on the equivalence of questionnaire items. *Journal of Educational Measurement*, *19*(4), 317–322. https://doi.org/10.1111/j.1745-3984.1982.tb00137.x
Landis, J. R., & Koch, C. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159–174. https://doi.org/10.2307/2529310
Lee, J., & Choi, H. (2017). What affects learner's higher-order thinking in technology-enhanced learning environments? The effects of learner factors. *Computers & Education*, *115*, 143–152. https://doi.org/10.1016/j.compedu.2017.06.015
Lin, J.-W., Tsai, C.-W., Hsu, C.-C., & Chang, L.-C. (2021). Peer assessment with group awareness tools and effects on project-based learning. *Interactive Learning Environments*, *29*(4), 583–599. https://doi.org/10.1080/10494820.2019.1593198
Lin, W., & Chapman, E. (2020). Development and preliminary evaluation of an instrument to measure readiness for problem-based Learning. *Journal of Problem-Based Learning*, *7*(2), 53–62. https://doi.org/10.24313/jpbl.2020.00262
Lu, K., Pang, F., & Shadiev, R. (2021). Understanding the mediating effect of learning approach between learning factors and higher order thinking skills in collaborative inquiry-based learning. *Educational Technology Research and Development*, 1–18. https://doi.org/10.1007/s11423-021-10025-4
Lubis, R. R., Irwanto, I., & Harahap, M. Y. (2019). Increasing learning outcomes and ability critical thinking of students through application problem based learning strategies. *International Journal for Educational and Vocational Studies*, *1*(6), 524–527. https://doi.org/10.29103/ijevs.v1i6.1679
Maxwell, A. E. (1970). *Basic statistics in behavioural research*. Penguin.
Meijer, H., Hoekstra, R., Brouwer, J., & Strijbos, J.-W. (2020). Unfolding collaborative learning assessment literacy: A reflection on current assessment methods in higher education. *Assessment & Evaluation in Higher Education*, *45*(8), 1222–1240. https://doi.org/10.1080/02602938.2020.1729696
Moore, G., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, *2*(3), 192–222. https://doi.org/10.1287/isre.2.3.192
Ng, O.-L., Ting, F., Lam, W. H., & Liu, M. (2020). Active learning in undergraduate mathematics tutorials via cooperative problem-based learning and peer assessment with interactive online whiteboards. *The Asia-Pacific Education Researcher*, *29*(3), 285–294. https://doi.org/10.1007/s40299-019-00481-1
Nokes-Malach, T. J., Richey, J. E., & Gadgil, S. (2015). When is it better to learn together? Insights from research on collaborative learning. *Educational Psychology Review*, *27*(4), 645–656. https://doi.org/10.1007/s10648-015-9312-8
Nsor-Ambala, R. (2022). The impact of collaborative learning approaches on assessment outcomes in an accounting theory class. *Accounting Education*, *31*(1), 1–38. https://doi.org/10.1080/09639284.2021.1944232
Nunnally, J. (1967). *Psychometric theory*. McGraw-Hill.
Panitz, T., & Panitz, P. (1998). Encouraging the use of collaborative learning in higher education. *University Teaching: International Perspectives*, 161–201. https://doi.org/10.4324/9780429459092-7
Quinlan, K. M., & Pitt, E. (2021). Towards signature assessment and feedback practices: A taxonomy of discipline-specific elements of assessment for learning. *Assessment in Education: Principles, Policy & Practice*, 1–17. https://doi.org/10.1080/0969594X.2021.1930447
Reeves, T. C., & Reeves, P. M. (2012). Designing online and blended learning. In L. Hunt & D. Chalmers (Eds.), *University teaching in focus: A learning-centred approach* (1st ed., pp. 112–127). Routledge. https://doi.org/10.4324/9780203079690-7
Roberts, C., Jorm, C., Gentilcore, S., & Crossley, J. (2017). Peer assessment of professional behaviours in problem-based learning groups. *Medical Education*, *51*(4), 390–400. https://doi.org/10.1111/medu.13151
Saleh, A., Yuxin, C., Hmelo-Silver, C. E., Glazewski, K. D., Mott, B. W., & Lester, J. C. (2020). Coordinating scaffolds for collaborative inquiry in a game-based learning environment. *Journal of Research in Science Teaching*, *57*(9), 1490–1518. https://doi.org/10.1002/tea.21656

Schiefele, U. (1991). Interest, learning and motivation. *Educational Psychologist*, *26*, 299–323. https://doi.org/10.1080/00461520.1991.9653136

Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review*, *13*(1), 23–52. https://doi.org/10.1023/A:1009004801455

Shi, Y., Zhang, J., Yang, H., & Yang, H. H. (2021). Effects of interactive whiteboard-based instruction on students' cognitive learning outcomes: A meta-analysis. *Interactive Learning Environments*, *29*(2), 283–300. https://doi.org/10.1080/10494820.2020.1769683

Shroff, R. H., Ting, F. S. T., Lam, W. H., Cecot, T., Yang, J., & Chan, L. K. (2021). Conceptualization, development and validation of an instrument to measure learners' perceptions of their active learning strategies within an active learning context. *International Journal of Educational Methodology*, *7*(1), 201–223. https://doi.org/10.12973/ijem.7.1.201

Stančić, M. (2021). Peer assessment as a learning and self-assessment tool: A look inside the black box. *Assessment & Evaluation in Higher Education*, *46*(6), 852–864. https://doi.org/10.1080/02602938.2020.1828267

Sugeng, B., & Suryani, A. W. (2020). Enhancing the learning performance of passive learners in a financial management class using problem-based learning. *Journal of University Teaching & Learning Practice*, *17*(1). https://doi.org/10.53761/1.17.1.5

Tâm, N. T. M. (2021). Using problem-based tasks to promote higher-order thinking skills for TESOL MA students in Vietnam. *Interdisciplinary Journal of Problem-Based Learning*, *15*(1), Article 28772. https://doi.org/10.14434/ijpbl.v15i1.28772

Unal, E., & Cakir, H. (2021). The effect of technology-supported collaborative problem solving method on students' achievement and engagement. *Education and Information Technologies*, *26*(4), 4127–4150. https://doi.org/10.1007/s10639-021-10463-w

Van der Kleij, F. M., & Lipnevich, A. A. (2021). Student perceptions of assessment feedback: A critical scoping review and call for research. *Educational Assessment, Evaluation and Accountability*, *33*(2), 345–373. https://doi.org/10.1007/s11092-020-09331-x

Van der Pol, J., Van den Berg, B., Admiraal, W. F., & Simons, P. R.-J. (2008). The nature, reception, and use of online peer feedback in higher education. *Computers & Education*, *51*(4), 1804–1817. https://doi.org/10.1016/j.compedu.2008.06.001

Xie, K., Hensley, L. C., Law, V., & Sun, Z. (2019). Self-regulation as a function of perceived leadership and cohesion in small group online collaborative learning. *British Journal of Educational Technology*, *50*(1), 456–468. https://doi.org/10.1111/bjet.12594

Xiong, Y., So, H.-J., & Toh, Y. (2015). Assessing learners' perceived readiness for computer-supported collaborative learning (CSCL): A study on initial development and validation. *Journal of Computing in Higher Education*, *27*(3), 215–239. https://doi.org/10.1007/s12528-015-9102-9

Zhu, C. (2012). Student satisfaction, performance, and knowledge construction in online collaborative learning. *Journal of Educational Technology & Society*, *15*(1), 127–136. http://www.jstor.org/stable/jeductechsoci.15.1.127

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Appendix

Collaborative problem-based learning and peer assessment strategies inventory (CO-PBLa-PA-SI)

Background

Please [√] only one answer for the following questions.

1. **In general, how confident are you in learning without the use of technology in class?**
☐ Very Confident ☐ Somewhat Confident ☐ Confident ☐ Less Confident ☐ Not Confident

2. **In general, how confident are you in learning without the use of technology after completing this course?**
☐ Very Confident ☐ Somewhat Confident ☐ Confident ☐ Less Confident ☐ Not Confident

3. **How much of your class time do you prefer to learn without technology in another course?:**
☐ 80-100% ☐ 60-79% ☐ 40-59% ☐ 20-39% ☐ 0-19%

4. **Do you prefer to learn without the use of technology in class?**
☐ Yes ☐ No

5. **Before this course, how much experience do you have in learning with the use of technology?:**
☐ High experience ☐ Moderate experience ☐ Low experience

6. **Before this course, how much experience do you have in learning without the use of technology?:**
☐ High experience ☐ Moderate experience ☐ Low experience

7. **Your Gender:**
☐ Male ☐ Female

8. **Your year in school:**
☐ 1 ☐ 2 ☐ 3 ☐ 4

Using the following scale, (7 = Strongly Agree 6 = Moderately Agree 5 = Slightly Agree 4 = Neither Agree nor Disagree 3 = Slightly Disagree 2 = Moderately Disagree 6 = Strongly Disagree), **please circle the number that indicates your level of agreement with the following statements:**

		Strongly Agree	Moderately Agree	Slightly Agree	Neither Agree nor Disagree	Slightly Disagree	Moderately Disagree	Strongly Disagree
9	I felt the activity allowed me to effectively work together on a task.	7	6	5	4	3	2	1
10.	I felt a sense of willingness to take part in problem-solving tasks by actively sharing knowledge	7	6	5	4	3	2	1
11.	I found it positively beneficial to share work with other group members for constructive feedback.	7	6	5	4	3	2	1

12.	I was committed to achieving the goals of the task by expending more effort.	7	6	5	4	3	2	1
13.	I am more apt to work together in a group by taking into account different points of views of others.	7	6	5	4	3	2	1
14.	I felt the activity allowed me to realize the usefulness of group feedback in supporting my learning with peers.	7	6	5	4	3	2	1
15.	I am more predisposed to exploring ideas by working together in a group than on my own.	7	6	5	4	3	2	1
16.	I was willing to exert effort by persisting at tasks I found challenging.	7	6	5	4	3	2	1
17.	I was favorably inclined toward receiving prompt feedback from group members.	7	6	5	4	3	2	1
18.	I was able to effectively interact by contributing information from multiple viewpoints.	7	6	5	4	3	2	1
19.	I felt working together in a group deepened my understanding of the topic.	7	6	5	4	3	2	1
20.	I was eager to engage in thought-provoking tasks that elicit deeper levels of thought.	7	6	5	4	3	2	1
21.	I felt the activity aroused my curiosity by prompting me to probe further.	7	6	5	4	3	2	1
22.	I found merit in taking into account group members' evaluations of each group's solutions to the task	7	6	5	4	3	2	1
23.	I felt the activity allowed me to effectively interact in an open-exchange of ideas.	7	6	5	4	3	2	1
24.	I found the task elicited a sense of appeal.	7	6	5	4	3	2	1