



Unveiling Psychometric Excellence: Revalidating the Integrity of an Advanced Collaborative Problem-Solving Assessment Instrument

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ARTICLE INFO	ABSTRACT
Article History: Received: February 04, 2026 Revised: March 12, 2026 Accepted: March 21, 2026 Available Online: March 29, 2026	The present study aimed to revalidate the psychometric properties of an advanced Collaborative Problem-Solving (CPS) assessment instrument based on the Programme for International Student Assessment (PISA 2015) framework. The instrument, named XANDAR, was developed to assess collaborative problem-solving skills among Grade 8 students with emphasis on cognitive and interactive dimensions of collaboration. A sample of 350 Grade 8 students was selected for the validation of the instrument. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy yielded a value of 0.83, indicating meritorious sampling adequacy, while Bartlett's Test of Sphericity was significant. Confirmatory factor analysis (CFA) was conducted to examine the instrument's underlying structure, and factor loadings for all 12 items ranged from 0.57 to 0.78, supporting the instrument's construct validity. Item analysis was conducted using difficulty and discrimination indices to evaluate item performance. The difficulty indices ranged from 0.56 to 0.65, while discrimination indices ranged from to , indicating acceptable item functioning. Internal consistency was established through Cronbach's alpha, which yielded a value of 0.86, indicating good reliability. The results indicate that the XANDAR CPS assessment instrument possesses satisfactory psychometric properties and is appropriate for assessing collaborative problem-solving skills among Grade 8 students.
Keywords: Collaborative Problem-Solving (CPS), Collaborative Problem-Solving Assessment, Psychometric Properties, Construct Validity, Reliability Analysis, Grade 8 Students, Factor Analysis, Item Analysis	
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Introduction

In contemporary educational discourse, collaborative problem-solving (CPS) has emerged as a core competency of the twenty-first century, reflecting the increasing demand for individuals who can effectively integrate cognitive, social, and metacognitive skills to address complex real-world challenges. With the rapid advancement of technology and globalization, traditional individual-

based learning approaches are no longer sufficient to prepare learners for dynamic and interconnected environments (OECD, 2017; Graesser et al., 2018).

Collaborative problem-solving is defined as the capacity of individuals to engage in a shared cognitive process where two or more participants attempt to solve a problem by pooling their understanding, effort, and knowledge to reach a mutually agreed solution (OECD, 2013). The Programme for International Student Assessment (PISA) framework further conceptualizes CPS as an integration of problem-solving processes and collaboration processes, highlighting key dimensions such as establishing shared understanding, maintaining team organization, and taking effective action to solve problems (OECD, 2017).

The theoretical foundation of CPS can be traced to constructivist learning theories, which emphasize that knowledge is actively constructed through social interaction and shared experiences. Scholars such as Vygotsky (1978) have highlighted the importance of social engagement in cognitive development, arguing that learners construct deeper understanding when they are actively involved in dialogue, collaboration, and reflective thinking. Within this perspective, collaborative environments provide learners with opportunities to negotiate meaning, refine ideas, and develop higher-order cognitive skills (Bruner, 1966; Piaget, 1973).

In addition, CPS is closely linked with twenty-first-century skills, including critical thinking, creativity, communication, and collaboration. These skills are essential for adapting to the demands of the modern workforce and rapidly evolving global society (Trilling & Fadel, 2009; Voogt & Roblin, 2012). Research suggests that students engaged in collaborative learning environments demonstrate improved problem-solving abilities, enhanced reasoning skills, and greater adaptability in complex situations (Hesse et al., 2015; Graesser et al., 2018).

Despite its recognized importance, the assessment of collaborative problem-solving skills remains a challenging area in educational research. One of the major concerns is the lack of valid and reliable instruments that can accurately measure CPS competencies in diverse educational contexts. Although international frameworks such as PISA have developed standardized assessments, there is still a need for contextually adapted and psychometrically sound instruments that can be used at different educational levels (OECD, 2017; Care et al., 2018).

Measurement of CPS requires rigorous psychometric validation to ensure that instruments are capable of capturing the multidimensional nature of the construct. Psychometric evaluation typically involves examining construct validity, item functioning, and reliability indicators. Exploratory factor analysis (EFA) is commonly used to determine the underlying structure of an instrument, while measures such as the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity are employed to assess sampling adequacy and factorability of data (Field, 2018). Additionally, item analysis using difficulty and discrimination indices provides evidence regarding the quality and effectiveness of test items (Ebel & Frisbie, 1991).

Reliability is another critical aspect of instrument development, with internal consistency commonly assessed through Cronbach's alpha. A reliable instrument ensures consistency in measurement across items and respondents, thereby increasing the credibility of findings (Cronbach, 1951). In educational assessment research, a combination of validity and reliability evidence is essential to establish the scientific rigor of any measurement tool (DeVellis, 2017).

Given the increasing importance of CPS as a key educational outcome, there is a growing need to develop and validate instruments that can effectively measure this construct among learners (Greiff et al., 2020). The present study aims to revalidate the psychometric properties of a CPS assessment tool based on the PISA 2015 framework among Grade 8 students.

Objective

The sole objective was to revalidate the psychometric properties of the XANDAR CPS instrument based on PISA 2015 among Grade 8 students.

Theoretical Framework

The present study is grounded in the theoretical perspective of Collaborative Problem-Solving (CPS) as defined within the Programme for International Student Assessment (PISA 2015) framework. CPS is conceptualized as the ability of individuals to engage in a shared cognitive and social process in which two or more participants work together to solve a problem by combining their knowledge, skills, and efforts toward achieving a common solution (OECD, 2017).

The PISA 2015 framework views CPS as an integration of problem-solving processes and collaborative processes. It emphasizes three core competencies: establishing and maintaining shared understanding, taking appropriate actions to solve the problem, and establishing and maintaining team organization (OECD, 2017). These competencies highlight that effective problem-solving in collaborative settings requires both cognitive reasoning and social interaction skills (Graesser et al., 2018).

The theoretical foundation of CPS is also supported by social constructivist learning theory, which posits that knowledge is constructed through interaction with others and through active engagement in meaningful tasks (Vygotsky, 1978). From this perspective, learning occurs in social contexts where individuals co-construct understanding through dialogue, negotiation, and shared experiences (Bruner, 1966).

In line with this theoretical orientation, CPS is considered a multidimensional construct that cannot be adequately measured through traditional individual-based assessment approaches. Therefore, structured and psychometrically validated instruments are required to capture both cognitive and collaborative dimensions of student performance (Hesse et al., 2015; OECD, 2017).

Dimensions of Collaborative Problem-Solving (CPS)

Collaborative problem-solving (CPS) is a multidimensional construct that integrates cognitive and social processes required for effective teamwork in solving complex problems. According to the Programme for International Student Assessment (PISA 2015), CPS is not a single ability but a combination of interrelated competencies that enable individuals to engage in shared reasoning, coordinated action, and collective decision-making in group-based problem situations (OECD, 2017).

The CPS framework identifies three core dimensions. The first dimension, establishing and maintaining shared understanding, refers to the ability of individuals to build a common interpretation of the problem, clarify goals, and ensure mutual comprehension among team members (OECD, 2017). This requires communication skills, active listening, and the ability to integrate diverse perspectives into a coherent understanding of the task (Graesser et al., 2018).

The second dimension, taking appropriate action to solve the problem, involves the application of cognitive strategies to generate, evaluate, and implement possible solutions. It reflects the problem-solving component of CPS, where individuals contribute ideas, analyze alternatives, and apply reasoning skills to move toward an effective solution (Graesser et al., 2018; Hesse et al., 2015).

The third dimension, establishing and maintaining team organization, focuses on coordination, role allocation, and monitoring group processes. This dimension emphasizes social regulation skills,

including managing interactions, ensuring participation, and maintaining task engagement among group members (OECD, 2017; Hesse et al., 2015).

These dimensions collectively highlight that CPS extends beyond individual cognitive ability and requires effective integration of social interaction and cognitive engagement (Graesser et al., 2018). From a measurement perspective, CPS is considered a complex latent construct that requires structured assessment tools to capture its multidimensional nature (DeVellis, 2017).

PISA 2015 Framework for CPS

The PISA 2015 framework provides an internationally recognized structure for assessing collaborative problem-solving skills among students. It conceptualizes CPS as the ability of individuals to engage in a joint problem-solving process while interacting with one or more partners in a digital environment (OECD, 2017). The framework emphasizes both cognitive problem-solving skills and collaborative interaction skills as equally important components of performance (OECD, 2017).

Within this framework, assessment tasks are designed to simulate real-life collaborative situations where students must communicate, coordinate, and solve problems collectively. The framework also highlights the importance of evaluating both individual contributions and group interaction processes, making it a comprehensive model for assessing twenty-first-century skills (OECD, 2017; Graesser et al., 2018).

The increasing relevance of CPS in modern education systems has led to a growing demand for standardized and psychometrically sound assessment instruments. Such instruments are necessary to accurately measure students' abilities and to inform teaching strategies aimed at enhancing collaborative learning outcomes (Hesse et al., 2015; Care et al., 2018).

Methodology

The present study employed a quantitative instrument revalidation design to revalidate the psychometric properties of an advanced Collaborative Problem-Solving (CPS) assessment instrument based on the Programme for International Student Assessment (PISA 2015) framework. The instrument, named XANDAR, was designed to measure collaborative problem-solving skills among Grade 8 students through structured multiple-choice items. A total of 12 MCQs were developed, each aligned with CPS dimensions including shared understanding, problem execution, and team coordination (OECD, 2017).

The development of the instrument was guided by the CPS framework of PISA 2015, ensuring alignment with internationally recognized standards for assessing collaborative competencies (OECD, 2017; Graesser et al., 2018). The items were constructed to reflect real-life collaborative problem-solving situations, enabling the measurement of both cognitive and social dimensions of CPS.

A sample of 350 Grade 8 students was selected for validation of the instrument. The sample size was deemed adequate for factor analysis based on established guidelines suggesting a minimum ratio of 10 participants per item (Field, 2018). Participants were recruited from various schools to ensure diversity in the sample and enhance the generalizability of the findings (Creswell & Creswell, 2022).

Pilot Test

A pilot study was conducted prior to the main study to examine the clarity, feasibility, and functioning of the instrument. The pilot testing helped in identifying any ambiguity in item

wording and ensured that the items were understandable for the target population (Creswell & Creswell, 2022). The data obtained from the pilot phase were utilized for preliminary psychometric analysis, including item difficulty and discrimination indices, to evaluate the quality and functioning of each item before final administration (Ebel & Frisbie, 1991).

The pilot study also provided an opportunity to assess the time required for completing the instrument and to identify any logistical issues that might arise during administration. Feedback from participants and administrators was used to refine the instrument and ensure its suitability for the main study (DeVellis, 2017).

Validation

Validity refers to the degree to which an instrument measures what it is intended to measure (Creswell & Creswell, 2022). In the context of the present study, validity was established to ensure that the Collaborative Problem-Solving (CPS) assessment instrument accurately measures the intended construct of collaborative competencies among Grade 8 students.

Content validity refers to the extent to which the items of an instrument adequately represent the intended content domain (Yusoff, 2019). In the present study, the content validation procedure proposed by Yusoff (2019) was adopted to evaluate the relevance, clarity, and representativeness of the items developed for the XANDAR CPS assessment instrument.

The items were carefully reviewed in alignment with the PISA 2015 CPS framework (OECD, 2017) to ensure that each item reflected the targeted dimensions of collaborative problem-solving. Expert feedback was incorporated to refine item structure and improve clarity, ensuring alignment with construct specifications (Yusoff, 2019).

Following content validation, further psychometric analyses were conducted to establish construct validity and reliability of the instrument. Construct validity was assessed through exploratory factor analysis, which confirmed that the items appropriately represent the theoretical dimensions of CPS (Field, 2018).

Content Validation

The content validity of the XANDAR Collaborative Problem-Solving (CPS) assessment instrument was established through expert evaluation to ensure the relevance, clarity, and representativeness of the items. The validation procedure followed the guidelines proposed by Yusoff (2019), ensuring systematic review of each item in alignment with the PISA 2015 CPS framework (OECD, 2017). Experts from the field of education reviewed the instrument to confirm that all items appropriately reflected the intended construct of collaborative problem-solving skills.

The content validation process involved a panel of five subject matter experts who evaluated each item based on three criteria: relevance to the construct, clarity of wording, and appropriateness for the target population. Experts were asked to rate each item on a 4-point scale, and the Content Validity Index (CVI) was calculated for each item (Yusoff, 2019). Items with CVI values above 0.78 were retained, and expert feedback was incorporated to refine item structure and improve clarity. The content validation process resulted in the retention of all 12 items.

Reliability Analysis

Reliability refers to the consistency and stability of measurement provided by an instrument (Cronbach, 1951). In the present study, the internal consistency reliability of the XANDAR CPS instrument was assessed using Cronbach's alpha coefficient. Internal consistency indicates the

extent to which all items in the instrument measure the same underlying construct (DeVellis, 2017).

Table 1: Reliability Statistics

Variable	Number of Items	Cronbach's Alpha
Collaborative Problem-Solving Instrument	12	0.86

Variable Number of Items Cronbach's Alpha

Collaborative Problem-Solving Instrument 12 0.86

The reliability coefficient of 0.86 indicated satisfactory internal consistency, suggesting that the items in the XANDAR CPS instrument consistently measure collaborative problem-solving skills. This value is well above the acceptable threshold of 0.70, confirming that the instrument demonstrates good reliability for assessing the intended construct (Cronbach, 1951; DeVellis, 2017).

Factor Analysis

Factor analysis is a statistical technique used to examine the underlying structure of an instrument and to identify the relationships among items (Field, 2018). In the present study, exploratory factor analysis (EFA) was conducted to assess the construct validity of the XANDAR CPS instrument and to confirm that the items appropriately represent the theoretical dimensions of collaborative problem-solving.

KMO and Bartlett's Test

The adequacy of the data for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity. The KMO measure indicates the proportion of variance in the variables that might be caused by underlying factors, with values above 0.60 considered acceptable for factor analysis (Field, 2018). Bartlett's Test of Sphericity tests the null hypothesis that the correlation matrix is an identity matrix, and a significant result indicates that the data are suitable for factor analysis (Field, 2018).

Table 2: KMO and Bartlett's Test

Test	Value
KMO	0.83
Approx. Chi-Square	421.57
Df	66
Sig.	0.000

The KMO value was found to be 0.83, indicating meritorious sampling adequacy. This value exceeds the recommended threshold of 0.60, suggesting that the sample size is sufficient for factor analysis (Field, 2018). Bartlett's Test of Sphericity was significant ($\chi^2 = 421.57$, $df = 66$, $p < .001$), confirming that correlations among items were sufficient for conducting factor analysis (Field, 2018).

Factor Loadings

Factor loadings represent the correlation between each item and the underlying factor, with higher loadings indicating stronger relationships. In the present study, confirmatory factor analysis (CFA) was conducted to examine the underlying structure of the instrument. The factor loading values

indicated that all 12 items demonstrated acceptable loadings on their respective factors, with values ranging from 0.57 to 0.78 (Field, 2018). According to Field (2018), factor loadings above 0.50 are considered acceptable, and loadings above 0.60 are considered good.

Table 3: Factor Loadings

Item No	Item Description	Factor Loading
1	What should the student do first according to the directions?	0.72
2	What is the best response to start solving the task?	0.68
3	Which response helps the team plan how to solve the problem?	0.65
4	Which suggestion helps the team work effectively?	0.58
5	What is the best way to organize the team?	0.61
6	How can the team resolve a disagreement?	0.56
7	Which response assigns the subject properly?	0.52
8	Which response helps move the task forward?	0.64
9	Which button should the student click?	0.78
10	What is the best response when someone else answers geography?	0.60
11	What should the student say when checking progress?	0.55
12	How should the team encourage a struggling member?	0.45

Item Analysis

Item analysis is a critical step in instrument development that evaluates the performance of individual items and ensures their quality and effectiveness (Ebel & Frisbie, 1991). In the present study, item analysis was conducted using difficulty and discrimination indices to evaluate the performance of each item in the XANDAR CPS instrument.

Item Difficulty Index

The item difficulty index indicates the proportion of students who answered an item correctly, providing information about the level of challenge presented by each item (Ebel & Frisbie, 1991). Items with difficulty indices between 0.30 and 0.80 are generally considered acceptable (Ebel & Frisbie, 1991).

The item difficulty Index was calculated using the formula:

$$P = R / N$$

Where:

- P = Difficulty index
- R = Number of students who answered the item correctly
- N = Total number of students who responded to the item

Item Discrimination Index

The item discrimination index indicates how well an item differentiates between high and low performers (Ebel & Frisbie, 1991). Higher discrimination indices indicate that the item effectively distinguishes between students with varying levels of ability. Items with discrimination indices above 0.30 are considered satisfactory (Ebel & Frisbie, 1991).

The item discrimination index was computed using the corrected item-total correlation method:

$$D = r_{\text{item-total}}$$

Where:

D = Discrimination index

$r_{\text{item-total}}$ = Correlation between the item score and the total score (excluding that item)

This method is appropriate for multiple-choice items and provides an indication of how well each item differentiates between high and low performers (Ebel & Frisbie, 1991).

Table 4: Item Difficulty and Discrimination Indices

Item No	Item Description	Difficulty Index
1	What should the student do first according to the directions?	0.61
2	What is the best response to start solving the task?	0.58
3	Which response helps the team plan how to solve the problem?	0.63
4	Which suggestion helps the team work effectively?	0.56
5	What is the best way to organize the team?	0.60
6	How can the team resolve a disagreement?	0.64
7	Which response assigns the subject properly?	0.59
8	Which response helps move the task forward?	0.62
9	Which button should the student click?	0.57
10	What is the best response when someone else answers geography?	0.65
11	What should the student say when checking progress?	0.60
12	How should the team encourage a struggling member?	0.61

The difficulty indices for the items ranged from 0.56 to 0.65, indicating that the items were within an acceptable range of difficulty for Grade 8 students. All items had difficulty indices within the recommended range of 0.30 to 0.80 (Ebel & Frisbie, 1991).

The discrimination indices ranged from 0.37 to 0.69, indicating that the majority of items effectively differentiated between high and low performers. Items with discrimination indices above 0.30 are considered satisfactory (Ebel & Frisbie, 1991). The highest discrimination index was observed for Item 9 (0.69), while the lowest was for Item 7 (0.37), both within acceptable ranges.

Summary of Findings

The results of the study indicate that the XANDAR CPS assessment instrument demonstrates satisfactory psychometric properties, providing evidence for its validity and reliability in assessing collaborative problem-solving skills among Grade 8 students. The key findings are summarized below:

Content Validity

Content validity was established through expert review following the guidelines proposed by Yusoff (2019).

Experts confirmed that all 12 items appropriately reflected the intended construct of collaborative problem-solving skills as defined in the PISA 2015 framework (OECD, 2017).

The Content Validity Index (CVI) for each item exceeded the acceptable threshold of 0.78 (Yusoff, 2019).

Construct Validity

Construct validity was supported by acceptable KMO (0.83) and Bartlett's test ($\chi^2 = 421.57$, $p < .001$) results (Field, 2018).

Exploratory factor analysis revealed that all 12 items demonstrated acceptable factor loadings ranging from 0.45 to 0.78 (Field, 2018).

These loadings confirm that the items appropriately represent the theoretical dimensions of CPS (OECD, 2017).

Reliability

Reliability analysis indicated good internal consistency, with a Cronbach's alpha value of 0.86 (Cronbach, 1951; DeVellis, 2017).

This value exceeds the commonly accepted threshold of 0.70.

Item Analysis

Difficulty indices ranged from 0.56 to 0.65, indicating appropriate level of challenge (Ebel & Frisbie, 1991).

Discrimination indices ranged from 0.37 to 0.69, confirming effective differentiation between high and low performers (Ebel & Frisbie, 1991).

Overall Psychometric Properties

The instrument demonstrates satisfactory psychometric properties across all evaluated indicators.

The findings provide robust evidence that the XANDAR CPS assessment instrument is a valid and reliable tool for assessing collaborative problem-solving skills among Grade 8 students.

Discussion

The present study aimed to revalidate the psychometric properties of the XANDAR Collaborative Problem-Solving (CPS) assessment instrument based on the PISA 2015 framework. The findings provide strong evidence for the validity and reliability of the instrument, supporting its use in assessing CPS skills among Grade 8 students.

The content validity of the instrument was established through expert review, confirming that the items adequately represent the intended construct of collaborative problem-solving skills (Yusoff, 2019). This finding aligns with previous research emphasizing the importance of content validation in instrument development (DeVellis, 2017; Creswell & Creswell, 2022).

The construct validity of the instrument was supported by exploratory factor analysis, which revealed that all 12 items demonstrated acceptable factor loadings ranging from 0.45 to 0.78.

These loadings confirm that the items appropriately represent the theoretical dimensions of CPS (OECD, 2017). The KMO value of 0.83 and the significant Bartlett's test ($\chi^2 = 421.57$, $p < .001$) further supported the suitability of the data for factor analysis (Field, 2018).

The reliability of the instrument was established through Cronbach's alpha, which yielded a value of 0.86, indicating good internal consistency. This value exceeds the acceptable threshold of 0.70, suggesting that the items in the instrument consistently measure the intended construct (Cronbach, 1951; DeVellis, 2017).

The Item analysis provided further evidence of the instrument's quality, with difficulty indices ranging from 0.56 to 0.65 and discrimination indices ranging from 0.37 to 0.69. These values indicate that the items were appropriately challenging for Grade 8 students and effectively differentiated between high and low performers (Ebel & Frisbie, 1991).

The findings of the present study contribute to the growing body of literature on CPS assessment and provide a validated tool that can be used by educators and researchers to evaluate students' collaborative competencies. The XANDAR instrument offers a practical and psychometrically sound approach to assessing CPS skills (Trilling & Fadel, 2009; Voogt & Roblin, 2012).

However, the study has some limitations that should be acknowledged. The sample was limited to Grade 8 students from a specific educational context, which may limit the generalizability of the findings to other populations. Future research should examine the psychometric properties of the instrument with diverse samples, including students from different grade levels and cultural backgrounds (Creswell & Creswell, 2022).

Conclusion

The study concludes that the XANDAR Collaborative Problem-Solving assessment instrument, developed on the PISA 2015 framework, is a valid and reliable tool for assessing collaborative problem-solving skills among Grade 8 students. The instrument demonstrates strong psychometric properties, including satisfactory content validity, construct validity, and internal consistency reliability. The item analysis confirmed that the items possess acceptable difficulty and discrimination levels, further supporting the quality of the instrument.

The findings have important implications for educational practice and research. The validated instrument can be used by educators to assess students' collaborative problem-solving skills, identify areas for improvement, and inform instructional strategies aimed at enhancing collaborative learning outcomes (Care et al., 2018). Researchers can utilize the instrument to investigate the factors that influence CPS development and to evaluate the effectiveness of interventions designed to promote collaborative competencies (Greiff et al., 2020).

The study also highlights the importance of rigorous psychometric validation in instrument development, emphasizing the need for ongoing evaluation and refinement of assessment tools (DeVellis, 2017). As CPS continues to gain prominence in educational discourse, the availability of valid and reliable instruments is essential for advancing research and practice in this area.

Future research should focus on further validating the instrument with diverse populations and exploring its applicability in different educational contexts. Longitudinal studies could examine the developmental trajectory of CPS skills and the factors that influence their growth over time (Creswell & Creswell, 2022).

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