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Measurement Evidence for Collaboration, Feedback, Self-Efficacy, and Academic Stress in Project-Based Learning Management

Muhammad Yusuf[1*], Dian Arisandy Eka Putra Sembiring[2], Muhammad Fauzan[3], Lely Mardiyanti[4], Robi Hendra[5], Hansein Arif Wijaya[6]
[1234] Faculty of Teacher Training and Education, Universitas Jambi, Jambi, Indonesia

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ABSTRACT

Project-Based Learning (PjBL) has become one of the most widely adopted instructional approaches for developing twenty-first-century competencies. However, its implementation often exposes students to academic stress due to intensive collaboration, project deadlines, and continuous assessment. Although collaboration skills, lecturer feedback, self-efficacy, and academic stress have been widely investigated, evidence regarding the psychometric quality of instruments measuring these constructs within the context of PjBL remains limited. This study aimed to provide measurement evidence for four constructs associated with Project-Based Learning management among undergraduate biology education students. A quantitative instrument validation design was employed involving four expert validators for content validation and 59 students for pilot testing. Content validity was evaluated using the Item-Level Content Validity Index (I-CVI), Scale-Level Content Validity Index (S-CVI/Ave), and modified kappa coefficient (K*). Subsequently, the measurement model was assessed through Confirmatory Composite Analysis (CCA) within the Partial Least Squares Structural Equation Modeling (PLS-SEM) framework. The results demonstrated excellent content validity, with an S-CVI/Ave of 0.91 and modified kappa values ranging from 0.667 to 1.000. After refinement of indicators with low outer loadings, all constructs demonstrated satisfactory psychometric properties, including Composite Reliability values ranging from 0.89 to 0.94, Average Variance Extracted values between 0.508 and 0.633, and HTMT values below 0.85, indicating adequate convergent and discriminant validity. These findings provide empirical evidence that the instrument possesses satisfactory validity and reliability for measuring collaboration skills, lecturer feedback, self-efficacy, and academic stress within the context of Project-Based Learning. The validated instrument provides a sound foundation for future structural model testing examining the relationships among these constructs.

Corresponding Author: yusufyahya@unja.ac.id

INTRODUCTION

21st-century higher education demands that students not only master academic content but also possess generic skills such as critical thinking, problem-solving, communication, and collaboration (Greenstein, 2012). One learning model widely believed to be able to accommodate these demands is Project-Based Learning (PjBL), an active learning model that places students at the center of the learning process through the completion of real-life projects (Muhammad, 2020; Hussin et al., 2019). Through PjBL, students are trained to work collaboratively in teams (Rasyid & Khoirunnisa, 2021), solve authentic problems (Amalia et al., 2022; Chiang & Lee, 2016), and improve their overall learning outcomes (Fauzia & Prastiti, 2017).

However, the implementation of PjBL is not without consequences. The characteristics of PjBL, which demands active involvement, intensive teamwork, project deadlines, and continuous evaluation, have the potential to cause psychological distress for students, known as academic stress (Culclasure et al., 2019; Chyu & Chen, 2022). Academic stress is essentially an anxiety response arising from academic demands, the drive to achieve high performance, and the pressure of deadlines for assignments or projects (Chyu & Chen, 2022). If not managed properly, this condition can impact mental health, learning motivation, and even student academic achievement (Aziz & Khan, 2022; Ali et al., 2021; Tom, 2022; Kim & Park, 2021), and can be exacerbated when learning takes place under conditions that require rapid adjustment, such as those seen during distance learning (Rodríguez-Rivero et al., 2021).

This phenomenon is becoming increasingly relevant in the context of Biology Education students, given the nature of courses in this field, which are heavily saturated with practical work, laboratory- and field-based project assignments, and a relatively high academic load. When Project-Based Learning (PjBL) is widely implemented in the curriculum, students' ability to manage academic stress becomes a crucial factor in determining the success of the learning process and outcomes. Therefore, it is crucial to identify factors that contribute to students' ability to manage academic stress during project-based learning.

Several previous studies have shown that the ability to work in a team (collaboration) contributes to stress management (Sorensen et al., 2024), and the quality of this collaboration is also influenced by the role of the lecturer in the learning process (Nazari & Far, 2019). Furthermore, students' self-confidence, or self-efficacy, has been shown to be associated with academic burnout levels (Hendra et al., 2025) and positively influence learning outcomes (Latifah & Supriyadi, 2024). Lecturer feedback is also known to play a crucial role in supporting the overall learning process (Pradana, 2023). However, these studies generally discuss these three variables (collaboration, self-efficacy, and lecturer feedback) separately, and there is limited research that integrates them simultaneously within a single structural model to explain student academic stress management in the context of project-based learning. Based on these gaps, this article is designed to present empirical evidence (measurement evidence) regarding the relationship between collaboration skills, lecturer feedback, self-efficacy, and academic stress among Biology Education students in project-based learning. More specifically, the literature review in the following section aims to conceptually position these four constructs as a basis for developing a measurement model and research hypothesis.

LITERATURE REVIEW

Collaboration

Collaboration is a 21st-century skill and a key indicator of successful project-based learning (Greenstein, 2012; Barkley et al., 2014). In Project-Based Learning (PjBL), students are required to work collaboratively in groups to complete complex and authentic

projects. Therefore, this skill is not only a prerequisite but also an outcome of the learning process (Andriyani & Anam, 2022; Huysken et al., 2019). In their study of project-based courses at the graduate level, found that students' involvement in collaborative projects significantly improved their interdisciplinary, interpersonal, and conflict management skills from the beginning to the end of the course (Birdman et al., 2021).

In relation to stress management, collaboration serves as a source of social support that can ease students' cognitive and emotional burden when facing academic pressure (Sorensen et al., 2024). When students are able to build effective teamwork, project responsibilities and challenges can be distributed proportionally, thereby making individual stress more manageable. Conversely, failure to foster healthy collaboration can potentially increase the risk of interpersonal conflict and add to students' psychological burden during the project process. Therefore, collaboration skills are positioned as a crucial predictor of students' ability to manage academic stress in the PjBL context.

Lecturer Feedback

Lecturer feedback is a crucial component of the learning process, serving to guide, correct, and motivate students during project completion (Pradana, 2023; Tay & Lam, 2022). Constructive and timely feedback can help students understand their achievements and shortcomings, thus enhancing their learning (Copur-Gencturk et al., 2024). A recent study showed that the quality of lecturer feedback is closely related to students' self-regulation skills in learning, which in turn influences how students respond to the academic pressures they face (Tian et al., 2025).

In the context of Project-Based Learning (PjBL), lecturer feedback serves several roles. First, it serves as a means of formative evaluation of students' project progress. Second, it serves as a form of psychological support that can foster a sense of academic safety for students. When feedback is delivered supportively, students tend to interpret project challenges as learning opportunities rather than threats, thereby minimizing the potential for academic stress. Conversely, minimal feedback or judgmental feedback risks increasing students' anxiety about their academic performance (Tay & Lam, 2022).

Self-Efficacy

Self-efficacy refers to an individual's belief in their own ability to successfully complete a task or achieve a specific goal (Latifah & Supriyadi, 2024). In the academic realm, self-efficacy has been consistently shown to contribute to student learning outcomes (Honicke & Broadbent, 2016; Meng & Zhang, 2023), while also acting as a protective factor against academic stress and anxiety (Kristensen et al., 2023). Students with high self-efficacy tend to be more confident in facing challenging projects, have greater resilience to pressure, and are better able to manage their own learning strategies.

Previous studies have confirmed that self-efficacy significantly influences student academic engagement and plays a role in reducing anxiety levels during higher education (Lizarte Simón et al., 2024). Hendra et al. (2025) also revealed that self-efficacy is associated with academic burnout in students, where low self-efficacy contributes to increased fatigue, which can ultimately reduce stress management. Thus, self-efficacy is seen as one of the internal psychological resources that determines how students interpret and respond to academic demands in project-based learning.

Academic Stress

Academic stress is defined as an anxiety response arising from academic demands, pressure to achieve high levels of achievement, or time constraints in completing

assignments or projects (Chyu & Chen, 2022). Several studies have revealed that academic stress is negatively correlated with student academic achievement and mental health (Tom, 2022; Kim & Park, 2021; Ali et al., 2021). In active learning contexts such as PjBL, the challenge of academic stress becomes even more complex because students are required to engage intensively in problem-solving, teamwork, and continuous self-evaluation throughout the project cycle (Culclasure et al., 2019).

Academic stress management, in this context, refers to students' ability to recognize, manage, and respond adaptively to academic stress so that it does not develop into a disorder that hinders the learning process or outcomes. This ability does not exist in isolation but is influenced by various factors, both interpersonal, such as collaboration and feedback from lecturers, and intrapersonal, such as self-efficacy (Nazari & Far, 2019; Sorensen et al., 2024).

Unfortunately, as previously described, research that simultaneously integrates these three factors to explain students' academic stress management in the context of Project-Based Learning (PjBL) is still limited. This situation underlies the need to test a structural model that can comprehensively explain how collaboration skills, lecturer feedback, and self-efficacy collectively contribute to Biology Education students' ability to manage academic stress during project-based learning.

METHOD

Research Design

This study uses a quantitative approach. The aim of the study is to obtain evidence of the validity and reliability of instruments measuring four constructs in the context of Project-Based Learning (PjBL) management: collaboration skills, lecturer feedback, self-efficacy, and academic stress. The first stage is an evaluation of content validity through expert assessment using the Content Validity Index (CVI) and modified kappa coefficient (K*). The second stage is an empirical evaluation of the measurement model using Confirmatory Composite Analysis (CCA) within the Partial Least Squares Structural Equation Modeling (PLS-SEM) framework.

Research Participants

The study involved two groups of participants according to the stages of instrument evaluation. The first stage involved four validators who assessed the relevance of the instrument items. Expert assessment was used to evaluate the items' representation of the constructs being measured and became the basis for calculating the CVI. The second stage involved 59 active Biology Education students who had experience participating in project-based learning. Respondents were selected using a purposive sampling technique based on two criteria: (1) being an active Biology Education student and (2) having taken at least one course that implemented PjBL.

Research Procedure

The research procedure was implemented in five stages. First, a theoretical review and identification of instrument sources for each construct were conducted. Second, 30 initial items were compiled and grouped based on the construct and its dimensions. Third, the instruments were evaluated by four validators and a CVI analysis was performed. Fourth, the instruments that had undergone content validity evaluation were used in a pilot study of 59 students. The data obtained were then analyzed using CCA within a PLS-SEM

framework. Fifth, evidence of content validity and empirical evidence of the measurement model were interpreted in an integrated manner.

Instruments and Data Collection Techniques

The initial instrument consisted of 30 items covering four constructs. Collaboration skills consisted of 8 items (Greenstein, 2012), lecturer feedback consisted of 6 items (Gan et al., 2021), self-efficacy consisted of 6 items (Bandura, 2006), and academic stress consisted of 10 items (Bedewy & Gabriel, 2015). All items were structured as closed-ended statements and responded to using a Likert scale of 1-5. Data were then collected through a Google form distributed to respondents.

Data Analysis Technique

The study used Content Validity Assessment (CVI) and Confirmatory Composite Analysis (CCA) data analysis. The first stage was a content validity analysis based on the assessment results of four validators. At this stage, the CVI was calculated for each statement item. The analysis results were used to assess the relevance of the content and the level of agreement between the validators after correcting for the possibility of chance agreement. The second stage was an empirical evaluation of the measurement model using CCA within the PLS-SEM framework. The CCA evaluation covered four aspects: outer loading value, Cronbach's alpha, rho_A, composite reliability (rho_C), AVE, and Heterotrait-Monotrait Ratio (HTMT).

FINDINGS AND DISCUSSION

Findings

Content Validity Index

Content validity was conducted to evaluate the relevance of each item in measuring four constructs of project-based learning management: lecturer feedback, collaboration skills, self-efficacy, and academic stress. Four experts were involved in the assessment process of the 30-item instrument. Content validity analysis used the Item-Level Content Validity Index (I-CVI), see Table 1,

Table 1. CVI Test Results

No	Variable	Code	Statement Items	VI	V2	V3	V4	I-CVI	K*	Interpretation
1	Lecturer Feedback	LF1	The lecturer provided clear and specific feedback regarding my progress on the project I was working on.	1	1	1	1	1,00	1.000	Valid
2		LF2	The lecturer provided in-depth feedback on errors in the project approach, not just general comments.	1	1	0	1	0,75	0.667	Revised
3		LF3	The lecturer provided feedback that helped me understand how to improve the overall project outcome.	1	1	1	1	1,00	1.000	Valid
4		LF4	The lecturer gave me the opportunity to discuss the feedback given, so that I	1	1	1	1	1,00	1.000	Valid

No	Variable	Code	Statement Items	VI	V2	V3	V4	I-CVI	K*	Interpretation
			could better understand how to improve the project.							
5		LF5	The lecturer gave praise that motivated me to improve the quality and creativity in the project.	1	1	1	1	1,00	1.000	Valid
6		LF6	Praise from the lecturer made me feel appreciated and more confident in completing the project.	1	1	1	1	1,00	1.000	Valid
7	Collaboration Skills	CS1	I used my time effectively to complete the project assignments.	1	0	1	1	0,75	0.667	Revised
8		CS2	I actively contributed to completing the assigned tasks.	1	1	1	1	1,00	1.000	Valid
9		CS3	I listened to and valued the ideas of other team members.	0	1	1	1	0,75	0.667	Revised
10		CS4	I participated in discussions and exchanged ideas respectfully and openly.	1	1	1	1	1,00	1.000	Valid
11		CS5	I was able to reach a consensus despite differences of opinion.	1	0	1	1	0,75	0.667	Revised
12		CS6	When there were differences of opinion, I discussed them openly and sought the best solution.	1	1	1	1	1,00	1.000	Valid
13		CS7	I was able to make a significant contribution to the work being done.	1	1	1	1	1,00	1.000	Valid
14		CS8	I actively participated in all stages of the project (planning, implementation, evaluation).	1	1	1	1	1,00	1.000	Valid
15	Self-Efficacy	SE1	I feel confident in designing and implementing a biology project.	1	1	1	1	1,00	1.000	Valid
16		SE2	I am confident in overcoming challenges that arise during the project.	0	1	1	1	0,75	0.667	Revised
17		SE3	I am confident in collecting and analyzing relevant experimental data for the project.	1	1	1	1	1,00	1.000	Valid
18		SE4	I am confident in overcoming any technical problems or difficulties that arise during the project.	1	1	1	1	1,00	1.000	Valid
19		SE5	I feel confident in preparing a report or presentation of the project results.	1	1	1	0	0,75	0.667	Revised
20		SE6	I am confident in managing my time well during the project.	0	1	1	1	0,75	0.667	Revised
21	Academic Stress	AS1	I am able to manage the many tasks I have to complete in the project well.	1	1	1	1	1,00	1.000	Valid

No	Variable	Code	Statement Items	VI	V2	V3	V4	I-CVI	K*	Interpretation
22		AS2	I am able to handle the workload of the project without feeling overburdened.	1	1	1	1	1,00	1.000	Valid
23		AS3	I am confident in completing the project within the allotted time.	1	1	1	1	1,00	1.000	Valid
24		AS4	I am able to successfully complete all parts of the project.	0	1	1	1	0,75	0.667	Revised
25		AS5	I am able to confidently meet the expectations of my lecturers and classmates regarding the project results.	1	1	1	1	1,00	1.000	Valid
26		AS6	I feel confident in presenting the results of the biology project to the class.	1	1	1	1	1,00	1.000	Valid
27		AS7	I am able to effectively collect and analyze experimental data for the project.	1	1	0	1	0,75	0.667	Revised
28		AS8	I am able to effectively locate, select, and use the necessary references for the project.	1	1	1	1	1,00	1.000	Valid
29		AS9	I am able to effectively manage the responsibilities I carry out in my course projects.	1	1	1	0	0,75	0.667	Revised
30		AS10	I am able to work effectively in a team to complete my course projects.	1	1	1	1	1,00	1.000	Valid
			S-CVI					**0,91**		excellent

The analysis showed that 20 of the 30 items, or 66.67%, obtained an I-CVI score of 1.00, indicating full agreement among all validators regarding the item's relevance. Meanwhile, 10 items, or 33.33%, obtained an I-CVI score of 0.75, indicating that three of the four validators considered the item relevant. Overall, the instrument obtained an S-CVI/Ave score of 0.91, indicating content validity at the excellent scale level.

Modified kappa analysis provided additional evidence regarding the level of agreement between validators after adjusting for the possibility of chance agreement. Items with an I-CVI of 1.00 obtained a K* of 1.00, while items with an I-CVI of 0.75 obtained a K* of 0.667. Thus, all items fell into the good to excellent category. Based on the combination of theoretical coverage, S-CVI/Ave, and K*, all 30 items were retained for empirical testing in the pilot study.

Confirmatory Composite Analysis **(CCA)**

After evaluating content validity, empirical testing was conducted through Confirmatory Composite Analysis (CCA) using the PLS-SEM approach. Evaluation of the measurement model was carried out using loading range (outer loading), composite reliability (rho_C), and Average Variance Extracted (AVE).

Table 2. CCA Test Results

Construct	Retained Items	Loading Range	CR	AVE
Academic Stress	9	0.702–0.907	0.94	0,622
Collaboration Skills	7	0.668–0.820	0.89	0,508
Lecturer Feedback	5	0.760–0.883	0.91	0,633
Self-Efficacy	6	0.665–0.836	0.89	0,583

Following the removal of three indicators with low outer loadings (AS10, CLB3, and LF6), the psychometric properties of the measurement model improved. All constructs achieved Composite Reliability (CR) values above 0.70 and AVE values above 0.50, indicating that the refined measurement model satisfied the recommended criteria for internal consistency reliability and convergent validity.

Table 3. HTMT Test Results

	AS	CLB	LF	SE
AS				
CLB	0,193			
LF	0,201	0,566		
SE	0,194	0,612	0,789	

The HTMT values ranged from 0.193 to 0.789, all of which were below the recommended threshold of 0.85. These findings indicate that each construct demonstrated adequate discriminant validity, suggesting that the constructs measured distinct theoretical concepts. The highest HTMT value was observed between Lecturer Feedback and Self-Efficacy (0.789), reflecting a relatively strong conceptual relationship while remaining quite distinct. Conversely, the lowest HTMT value was found between Academic Stress Management and Collaboration Skills (0.193), indicating a clear conceptual separation between these constructs.

Discussion

This study aims to provide psychometric evidence for an instrument developed to measure collaboration skills, lecturer feedback, self-efficacy, and academic stress management in the context of Project-Based Learning (PjBL). Unlike most previous studies, which have focused on the impact of PjBL on learning outcomes, creativity, or 21st-century skills, this study focuses on developing an instrument capable of measuring the psychological and pedagogical factors that support the successful implementation of PjBL. Therefore, the validation process was carried out in stages, starting with content validity using expert assessment, followed by construct validity using Confirmatory Composite Analysis (CCA) based on Partial Least Squares Structural Equation Modeling (PLS-SEM). This stepwise approach aligns with the recommendations of Hair et al. (2020), who emphasize that instrument development must begin with a strong conceptual justification before empirical testing of the measurement model.

The content validation results indicate that the instrument is of excellent quality. All indicators achieved an Item-Level Content Validity Index (I-CVI) score between 0.75 and 1.00, while the Scale-Level Content Validity Index (S-CVI/Ave) reached 0.919. This value exceeds the minimum threshold of 0.90 recommended by Polit and Beck (2006) as an indicator of adequate content representation at the scale level. A high S-CVI/Ave value indicates a high level of agreement among the validators regarding the relevance of each indicator to the construct being measured. Therefore, conceptually, the instrument

adequately represents the key dimensions of collaboration skills, lecturer feedback, self-efficacy, and academic stress management, as formulated in the theoretical framework of this study.

Content validity in this study was strengthened through the use of Modified Kappa (K*), allowing evaluation to rely not only on the level of expert agreement but also on the possibility of chance agreement. Modified Kappa values ranged from 0.667 to 1.000, indicating a level of agreement in the good to excellent category. According to Polit, Beck, and Owen (2007), using Modified Kappa provides a more conservative estimate than I-CVI because it corrects for the chance of random agreement. Therefore, the combination of I-CVI, S-CVI/Ave, and Modified Kappa produces stronger evidence of content validity than using a single validity index alone. This approach is increasingly recommended in instrument development research because it can increase the credibility of validation results before the instrument is empirically tested.

Interestingly, several indicators achieved an I-CVI score of 0.75 with a Modified Kappa value of 0.667. Although lower than other indicators, all of these indicators are still within the acceptable category according to Polit et al. (2007). Therefore, this study did not immediately eliminate these indicators but instead conducted editorial revisions based on qualitative input from experts. This decision demonstrates that the instrument validation process relies not only on quantitative results but also considers the validators' conceptual arguments. This approach aligns with the principle of instrument development, which places content validity as an iterative process, where indicator quality is improved through repeated cycles of evaluation and refinement.

After obtaining evidence of content validity, the instrument was further evaluated using Confirmatory Composite Analysis (CCA). This analysis aims to ensure that the conceptually validated indicators also empirically represent the latent constructs. In the initial stage, the analysis results showed that three indicators—AS10, CLB3, and LF6—had outer loading values below the recommended limit of 0.70 and were therefore eliminated from the measurement model. Hair et al. (2021) explained that indicators with outer loadings below 0.70 have a relatively low contribution to the latent construct and therefore can be considered for removal if their removal improves the overall quality of the measurement model. Therefore, the removal of these three indicators was part of the instrument purification process (item purification) commonly performed in SEM-PLS-based psychometric research.

However, this study did not use outer loading values as the sole basis for decision-making. Several indicators, such as CLB1, CLB7, CLB8, and SE6, had loading values between 0.665 and 0.686, but were retained because they were within the acceptable range and had strong theoretical justification. Hair et al. (2021) emphasized that indicators with loadings between 0.60 and 0.70 can still be retained if the Composite Reliability and Average Variance Extracted values still meet the recommended criteria. This approach is crucial for maintaining a balance between the statistical quality of the model and the completeness of the conceptual representation of a construct. Therefore, the decision to retain an indicator is not solely based on numerical considerations but also on the substantive meaning of each indicator in relation to the construct being measured.

After the model refinement process, the construct reliability quality showed a significant improvement. All constructs had Composite Reliability (CR) values between 0.89 and 0.94, well above the minimum threshold of 0.70 recommended in the PLS-SEM literature (Hair et al., 2021). This value indicates that the retained indicators have high internal consistency in measuring their respective constructs. Furthermore, all CR values were below the upper limit of 0.95, thus preventing excessive indicator redundancy. In

other words, the remaining indicators provided complementary information without repeatedly measuring the same aspects.

The convergent validity test results also demonstrated satisfactory findings. Average Variance Extracted (AVE) values ranged from 0.508 to 0.633, all exceeding the minimum threshold of 0.50 as proposed by Fornell and Larcker (1981). These results indicate that each construct is able to explain more than half of the variance in its constituent indicators. The Lecturer Feedback construct had the highest AVE value (0.633), indicating that the indicators within this construct have a high degree of homogeneity in representing the concept of lecturer feedback. Conversely, Collaboration Skills had the lowest AVE value (0.508), although still above the recommended minimum limit. These values indicate that although the variation in indicators within the collaboration construct is relatively higher than that of the other constructs, all indicators are still able to adequately explain the construct's variance. These findings indicate that the refined measurement model has good convergent validity and is therefore suitable for use in the next stage of structural model testing.

In addition to convergent validity, this study also evaluated discriminant validity using the Heterotrait–Monotrait Ratio (HTMT). The HTMT approach was chosen because it is considered more sensitive in detecting discriminant validity issues than traditional methods such as the Fornell–Larcker criteria or cross-loading checks (Henseler et al., 2015). All HTMT values in this study ranged from 0.193 to 0.789, meaning all pairs of constructs had values below the 0.85 threshold. These findings indicate that each construct in the instrument is capable of empirically measuring different concepts, thus meeting the requirements for discriminant validity. Thus, the indicators for the Collaboration Skills, Lecturer Feedback, Self-Efficacy, and Academic Stress Management constructs do not overlap, although they are conceptually related in the project-based learning process.

The highest HTMT value was found in the relationship between Lecturer Feedback and Self-Efficacy (HTMT = 0.789). Statistically, this value is still below the maximum limit recommended by Henseler et al. (2015), so the two constructs can still be distinguished. However, this relatively stronger relationship compared to other pairs of constructs has a logical theoretical explanation. According to Bandura (2006), self-efficacy develops through various sources of experience, one of which is verbal persuasion, namely support, feedback, and reinforcement provided by others. In the context of higher education, lecturers are the primary source of verbal persuasion through their feedback on students' learning processes and outcomes.

Effective feedback not only informs students about their level of achievement but also helps them understand the steps they need to take to improve their academic performance. Therefore, the relatively high correlation between Lecturer Feedback and Self-Efficacy in this study reflects a strong conceptual relationship, without diminishing the functional differences between the two constructs. In contrast, the Academic Stress Management construct showed a very low HTMT value compared to all other constructs, ranging from 0.193 to 0.201. This value indicates that students' ability to manage academic stress is a psychological dimension that is clearly distinct from collaboration skills, lecturer feedback quality, and academic self-efficacy.

This finding strengthens the research conceptual framework that academic stress management is not a direct consequence of a single factor, but rather the result of the interaction of various personal factors and the learning environment. Kristensen et al. (2023) explained that academic stress is influenced by learning demands, task completion pressure, and an individual's ability to self-regulate. Therefore, although Collaboration Skills, Lecturer Feedback, and Self-Efficacy have the potential to contribute to academic

stress management, each remains a stand-alone construct with distinct measurement characteristics.

Overall, the discriminant validity results provide evidence that the measurement model has a clear construct structure and no conceptual overlap. This condition is an essential prerequisite before an instrument can be used to test structural relationships between variables using Structural Equation Modeling. Hair et al. (2021) emphasized that good discriminant validity ensures that each latent construct explains a unique phenomenon, ensuring that the estimated relationships between variables are not affected by conceptual multicollinearity issues. Therefore, the instrument developed in this study meets one of the key requirements for developing a SEM-PLS-based measurement model.

The findings of this study have important methodological implications for educational research, particularly in the context of Project-Based Learning (PjBL). To date, most research on PjBL has focused on the influence of learning models on learning outcomes, creativity, critical thinking skills, or 21st-century skills (Huysken et al., 2019). However, the quality of instruments used to measure psychological factors supporting PjBL implementation often receives less attention. Consequently, the interpretation of relationships between variables is less than optimal if the instrument used lacks adequate evidence of validity and reliability. This study attempts to fill this gap by providing an instrument that has undergone a systematic validation process, from content validity to construct validity.

The strength of this study lies not only in the use of Confirmatory Composite Analysis, but also in the integration of expert judgment and empirical testing within a single validation framework. This approach produces more comprehensive psychometric evidence than research that relies solely on internal reliability testing or exploratory factor analysis. Polit et al. (2007) emphasize that instrument development should begin with a conceptual evaluation through expert judgment before conducting statistical testing using empirical data. The approach applied in this study aligns with this principle, as each indicator is first evaluated for conceptual relevance and then retested through the quality of the measurement model using CCA. Thus, instrument validity is established through two complementary types of evidence: content validity evidence and construct validity evidence.

From a practical perspective, this validated instrument has the potential to be a useful measurement tool for lecturers and researchers to evaluate factors influencing the successful implementation of Project-Based Learning. Through this instrument, lecturers can not only identify students' levels of collaboration skills but also obtain information on the quality of learning feedback, their self-efficacy levels, and their ability to manage academic stress during project completion. This information can be used as a basis for designing more adaptive learning strategies, for example, by improving the quality of formative feedback, strengthening collaborative activities, or providing academic mentoring for students with low self-efficacy and experiencing high academic stress. Thus, this instrument has practical value as an evaluation tool and as a basis for decision-making in designing project-based learning.

However, this study has several limitations that require consideration. The empirical test was conducted on Biology Education students at a single university with a relatively limited number of respondents as part of a pilot study. Therefore, the results cannot be broadly generalized to various higher education contexts. Furthermore, the validation focused on the measurement model, thus the structural relationships between constructs were not evaluated. It is recommended that further research involve a larger number of respondents from various institutions and disciplines to test the stability of the

measurement model and assess measurement invariance between groups. Once the instrument has been proven stable across a broader population, subsequent research can utilize it to develop a structural model explaining the relationship between Collaboration Skills, Lecturer Feedback, Self-Efficacy, and Academic Stress Management in various Project-Based Learning implementations.

Overall, this study successfully provides evidence that the developed instrument has adequate psychometric quality, both in terms of content validity and construct validity. The combination of I-CVI, S-CVI/Ave, Modified Kappa, Confirmatory Composite Analysis, Composite Reliability, Average Variance Extracted, and Heterotrait–Monotrait Ratio analyses demonstrates that this instrument meets the criteria recommended in modern psychometric literature. Therefore, this instrument can be used as a valid and reliable measurement tool for further research focused on evaluating Project-Based Learning implementations and developing PLS-SEM-based structural models in education.

CONCLUSIONS

Based on this study, it is concluded that the Collaboration Skills, Lecturer Feedback, Self-Efficacy, and Academic Stress Management instruments in the context of Project-Based Learning (PjBL) have good psychometric qualities. The results of the study indicate that all constructs meet the criteria of content validity, internal reliability, convergent validity, and discriminant validity, so the instrument is considered suitable for use to measure the four constructs in the context of project-based learning. However, this study is still limited to an initial trial involving respondents from one study program so that generalization of the results needs to be done carefully. Further research is recommended to test this instrument on a larger and more diverse sample, covering various institutions and disciplines, and evaluate measurement invariance to ensure the stability of the instrument across various groups of respondents.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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