

Instrument Construction and Exploration of Students' Collaboration Skills Based on the Summated Rating Scale

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One of the essential 21st-century skills that students must possess is the ability to collaborate. However, profiling students' collaboration skills is challenging without valid and reliable instruments. Therefore, this research aims to map the profile of students' collaboration skills using valid and reliable instruments. This study is descriptive-explorative research with a quantitative approach. The research sample included 900 Islamic Senior High School/Madrasah Aliyah students, with 150 students participating in the instrument trials and 750 serving as the primary sample in this study. The results indicate that the collaboration ability instrument is valid and reliable, as demonstrated by a loading factor value > 0.5 , T-Value > 1.96 , RMSEA $0.00 < 0.08$, RMR 0.043, Std. RMR 0.040, GFI 0.95, AGFI 0.87, NNFI 0.97, CFI 0.98, IFI 0.98, RFI 0.97, PNFI 0.85, and a composite reliability coefficient $CR=0.909$ from the second-order confirmatory factor analysis. The findings show that students' collaboration skills are moderate, with an average score of 26.4, which falls within the medium category. The distribution of students' abilities is as follows: 347 students (46.3%) are classified as having moderate abilities, 207 students (27.6%) as having high skills, and 196 students (26.1%) as having low skills. Based on these results, teachers and stakeholders are encouraged to enhance students' collaboration skills through student-centred learning approaches, such as project-based learning, which can provide students with opportunities to engage and practice working together actively in the learning process.

Keywords: 21st-century skills, collaboration skills, summated rating scale

The rapid development of technology has impacted life in the 21st century. Changes in the reality of life are inevitable. Education plays a crucial role in shaping individuals to meet the demands of the current era. Therefore, the education system must equip students with knowledge, character, and skills aligned with the 21st century. (Malik et al., 2023). Trilling and Fadel (2009) state that there are four essential skills that students must develop in the 21st century: critical thinking, collaboration, communication, and creativity. This aligns with the Project to strengthen the Pancasila student profile (P5) implemented in Indonesia. The values instilled in the Project to strengthen the Pancasila student profile (P5) include being faithful and devoted to God Almighty, having noble character, being globally diverse, working together, being independent, thinking critically, and being creative. (Maisyaroh et al., 2023; Septinaningrum et al., 2022; Wulandari et al., 2023).

In the era of globalisation, collaboration skills have become one of the key competencies students need to succeed in both the workplace and everyday life. 21st-century education emphasises the importance of collaboration skills, as modern work environments require individuals who can work independently and collaborate with others to achieve common goals. According to Greenstein (2012), collaboration is considered one of the essential life skills, encompassing the ability to communicate effectively, resolve conflicts, build consensus, and work in teams. Therefore, it is crucial to ensure that these skills are measured with valid and reliable instruments so that the development of collaboration skills can be both monitored and enhanced.

However, measuring collaboration skills is not straightforward. Unlike cognitive skills, which can be assessed through written tests or exams, collaboration involves social and dynamic interactions that are challenging to measure directly. Previous research has attempted to develop instruments to measure collaboration, such as performance assessments, observations, and self-assessment rubrics. (Meier et al., 2007; Rummel & Spada, 2005). However, the validity and reliability of these instruments remain subjects of debate. Many existing instruments only evaluate certain aspects of collaboration, such as communication or problem-solving, and often fail to capture the complexity of social interactions during collaborative processes.

Research conducted by Johnson and Johnson (1994) shows that effective collaboration involves five key elements: positive interdependence, individual accountability, promotive interaction, social skills, and group processes. Measuring these five elements comprehensively requires an instrument that captures qualitative data from student interactions and provides quantitative data that can be analysed to gain a more complete picture of collaboration skills.

To address these challenges, developing instruments specifically designed to measure collaboration skills holistically is essential. These instruments must evaluate various aspects of collaboration, including verbal and non-verbal interactions and complex group dynamics. Additionally, these instruments should be applicable across various educational contexts, including elementary, secondary, and higher education levels. A well-designed instrument will enable educators to identify the strengths and weaknesses in students' collaboration skills so that more targeted educational interventions can be implemented.

In addition, developing this collaboration measurement instrument must also consider various factors that influence collaboration. For instance, culture, gender, and educational background can impact how students collaborate. According to Hofstede (1986), culture affects how individuals interact within groups. For example, collaboration tends to occur more naturally in collectivist cultures due to the strong values of togetherness. In contrast, in individualist cultures, individuals may focus more on achieving personal goals rather than group objectives. Therefore, the instruments developed must be sensitive to these cultural differences to interpret the measurement results accurately.

The development of measurement instruments must also consider technological aspects, especially with the growing integration of technology in the learning process. Digital technology offers new tools to observe and measure collaboration. For example, online learning platforms and digital communication tools can enable more prosperous and detailed data collection on collaborative interactions. The data gathered through these technologies can include communication patterns, frequency of interactions, and responses to conflicts within groups. However, new challenges arise when integrating this data into instruments that educators can practically use in the field.

In addition, exploring students' collaboration skills should be conducted longitudinally to understand how these skills develop over time. Longitudinal research can provide insights into the factors that support or hinder the development of collaborative abilities. For example, it can address whether more frequent collaborative experiences lead to improved collaboration skills or if it is a critical period in the development of collaboration that requires intervention. By understanding the dynamics of collaborative skill development, the instruments developed can be adjusted to accommodate these changes, making the measurements more accurate and relevant.

Research results also show that effective collaboration contributes to improved learning outcomes. (Roschelle & Teasley, 1995; Slavin, 2014, 2015). In education, collaboration enhances the understanding of the subject matter and fosters critical thinking skills, problem-solving abilities, and essential social skills. However, collaboration's impact on learning outcomes depends on how it is measured and understood. Therefore, developing the right instrument is crucial to ensure that the effects of collaboration on learning outcomes are accurately identified and maximised.

Based on the issues outlined above, developing instruments and exploring students' collaboration skills is a crucial step toward improving the quality of education. With valid and reliable instruments, educators can better understand the dynamics of collaboration in learning and apply more effective strategies to enhance students' collaboration skills. Additionally, an in-depth exploration of these skills will provide richer insights into how they evolve and how educational interventions can be designed to support their development. Thus, this research will significantly contribute to educational literature and practice in the field.

Method

This research employs a descriptive-exploratory design with a quantitative approach. Its objective is to explore and describe students' collaboration skills. The study sample included 900 students: 150 students for instrument testing and 750 students as the primary sample, distributed across 7 Islamic Senior High Schools/Madrasah Aliyah in 6 regencies/cities within the Bangka Belitung Islands Province. Sample selection was conducted using multi-stage sampling techniques. (Ackoff, 1953). This sampling method was chosen based on practicality, effectiveness, and efficiency, (Taherdoost, 2016).

The research began with developing a collaboration skills instrument based on the summated rating scale, which includes indicators such as working effectively with and respecting team members, adapting well, being responsible, and contributing to the team. (Trilling & Fadel, 2009). The instrument consists of 21 items with five response options: Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree. Respondents' answers were converted to z-scores. The validity of the instrument was assessed by five experts and analysed using the Aiken formula (Aiken, 1980, 1985). Empirical validity was evaluated through Confirmatory Factor Analysis and analysed with JASP software. An instrument item is considered valid if it has a loading factor greater than 0.5 (Azwar, 2016; Hair et al., 2010; Nurosis, 1986). Items with a loading factor less than 0.5 are deemed invalid. Reliability estimation was performed using composite reliability; a reliability coefficient close to 1 indicates that the instrument is reliable for measuring the construct, (Ramadhan et al., 2019; Vakili & Jahangiri, 2018).

Result and Discussion

The development of the instruments

The collaboration skills instrument was developed based on the indicators of collaboration skills proposed by Trilling and Fadel (2009). It was designed using a Likert scale with five response options. The instrument consists of 21 items that address the ability to work effectively, respect team members, adapt well, be responsible, and how one contributes to their team. The instrument grid is shown in Table 1.

Table 1
Collaboration Skills Instrument Framework

Indicator	Item	+/-
Work effectively and respect team members.	I respect the opinions expressed by group members.	+
	When making decisions, I consult with other group members to reach a consensus	+
	I accept decisions that have been agreed upon by the group.	+
	I reject decisions made by most group members.	-
	I would not say I like it when someone argues or disagrees with the ideas I propose	-
Adaptability	I do not choose my friends or group members.	+
	I am willing to work with friends or group members assigned by the teacher.	+
	I do not enjoy working with other people.	-
	I feel that my friends are unreliable.	-
Responsibility	My group members are pleased with me	+
	I am responsible for completing tasks by the agreed-upon deadline	+
	I prioritise group interests over personal interests.	+
	I am willing to undertake tasks determined through group discussion.	+
	Tasks assigned by the teacher are always completed on time	+
Contribute to the team	I am dissatisfied with the group's decision to distribute tasks.	-
	I participate in contributing ideas during discussions.	+
	I assist with group assignments given by the teacher.	+
	I provide feedback on ideas proposed by group members.	+
	I prefer to wait for the final results of group decisions rather than participating in discussions.	-
	I feel that group discussions only create problems	-
	I am involved in making decisions or reaching agreements in	+

Indicator	Item	+/-
the group.		

Table 1 shows the specifications of the developed collaboration capability instruments. The total of 21 instruments consists of 13 positive and eight negative items, using a Likert scale with five response options: strongly agree, agree, undecided/neutral, disagree, and strongly disagree.

Results of content validity analysis

Five experts appraised the validity of the research instrument in measuring student collaboration skills. The results of the expert assessment were analysed using the Aiken formula (Aiken, 1985). The results of the expert assessment for the 21 items of the collaboration skills instrument are shown in Table 2.

Table 2
Expert Judgement Results

Item	Validator					S1	S2	S3	S4	S5	ΣS	Aiken index
	1	2	3	4	5							
1	4	4	4	4	4	3	3	3	3	3	15	1.00
2	4	4	4	4	4	3	3	3	3	3	15	1.00
3	4	4	4	4	4	3	3	3	3	3	15	1.00
4	4	4	4	4	4	3	3	3	3	3	15	1.00
5	4	4	4	3	4	3	3	3	2	3	14	0.93
6	4	4	4	4	4	3	3	3	3	3	15	1.00
7	4	4	4	4	4	3	3	3	3	3	15	1.00
8	4	4	4	4	4	3	3	3	3	3	15	1.00
9	4	4	3	4	4	3	3	2	3	3	14	0.93
10	4	4	4	4	4	3	3	3	3	3	15	1.00
11	4	4	4	4	4	3	3	3	3	3	15	1.00
12	4	4	4	4	4	3	3	3	3	3	15	1.00
13	4	4	4	4	4	3	3	3	3	3	15	1.00
14	4	4	3	4	4	3	3	2	3	3	14	0.93
15	4	4	4	4	4	3	3	3	3	3	15	1.00
16	4	4	4	3	4	3	3	3	2	3	14	0.93
17	4	4	3	4	4	3	3	2	3	3	14	0.93
18	4	4	3	4	4	3	3	2	3	3	14	0.93
19	4	4	4	4	4	3	3	3	3	3	15	1.00
20	4	4	4	4	4	3	3	3	3	3	15	1.00
21	4	4	3	4	4	3	3	2	3	3	14	0.93
Mean												0.97

Table 2 shows that the collaboration skills instrument has an Aiken V index ranging from 0.93 to 1.00. Of the 21 items, 67% have an Aiken V index of 1.00, while the remaining 33% have an index of 0.93. Based on the expert assessment results, it can be stated that the collaboration skills instrument developed is classified as valid. This is confirmed by Aiken (1985), who states an instrument can be declared valid if five experts appraise it and the item has an Aiken V index > 0.87 .

Instrument Test Results

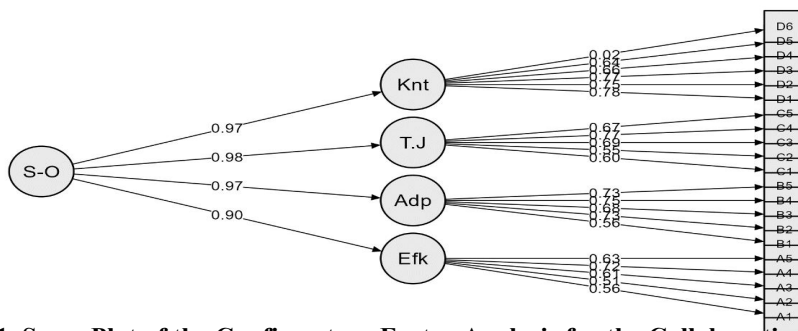
The collaboration skills instrument was tested on 150 Islamic Senior High School/Madrasah Aliyah students. The data obtained from this trial were used to determine the construct validity and reliability of the instrument. Construct validity was assessed using confirmatory factor analysis (CFA) with the JASP application. Before performing the CFA, the respondents' scores, originally in ordinal scale format, were converted to interval scale format using Z-scores based on the summated rating scale. The results of this conversion are presented in Table 3.

Table 3*Results of converting ordinal scale into interval scale*

Z+	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	D1	D2	D3	D4	D5	D6
SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0.6	0.9	0.9	0.5	0.8	0.6	0.7	0.7	0.5	0.5	0.8	0.7	0.6	0.5	0.8	0.6	0.7	0.9	0.8	0.9	0.9
U	0.9	1.4	1.5	0.9	1.3	1.2	1.2	1.4	1.3	0.9	1.3	1	1	1.3	1.5	0.8	1.2	1.5	1.2	1.4	1.5
A	1.3	1.9	2.1	1.5	2	1.8	1.9	2.3	2.2	1.6	1.9	1.5	1.6	2.1	2.3	1	1.7	2.1	1.7	1.9	2
SA	2.1	2.6	2.8	2.4	2.9	2.6	2.7	3.6	3.2	2.6	2.6	2.1	2.4	2.8	3.1	1.8	2.5	2.7	2.4	2.4	2.7

Based on Table 3, it is revealed that converting scores from an ordinal scale to an interval scale based on the summated rating scale affects the students' response scores. For instance, learners who initially scored 1 for item number 1 (A1), "Strongly Disagree (SD)", were converted to a score of 0, and students who responded "Agree (A)" to item 6 (B1), with an original score of 4, were converted to 1.8. This conversion process applies to all items up to item number 26. After all responses are converted to positive Z-scores, the resulting data is used to assess the validity and reliability of the construct through confirmatory factor analysis (CFA).

The results of the construct validity analysis, conducted using confirmatory factor analysis (CFA), are presented in Figure 1 and Table 4.

**Figure 1. Scree Plot of the Confirmatory Factor Analysis for the Collaboration Skills Instrument****Table 4**
Model Fit Criteria

Parameter	Value	Criteria	Conclusion
chi-square (χ^2)	0.775	$p > 0.05$	Fit
RMSEA	0.00	< 0.08	Fit
RMR	0.043	≤ 0.10	Fit
Std. RMR	0.040	≤ 0.10	Fit
GFI	0.95	≥ 0.90	Fit
AGFI	0.87	$0.80 \leq AGFI < 0.9$	Fit
NFI	0.90	≥ 0.90	Fit
NNFI	1	≥ 0.90	Fit
CFI	1	≥ 0.90	Fit
IFI	1	≥ 0.90	Fit
RFI	0.868	≥ 0.90	Fit
PNFI	0.77	> 0	Fit

Figure 1 shows the scree plot for a collaboration skills instrument consisting of 21 items across four factors: working effectively and respecting team members, adapting well, being responsible, and contributing to the team (Trilling & Fadel, 2009). Based on Figure 1, it can be observed that the factor loadings range from 0.02 to 0.78. The factor loadings between the dimensions of collaboration skills and the four factors range from 0.90 to 0.98, with a P-value of 0.77 ($p > 0.05$) and an RMSEA value of 0.00 ($RMSEA < 0.05$). The results indicate that out of the 21 items, only one item is invalid due to its factor loading of 0.02; that is, item 21. According to Hair et al. (2010), a factor loading is considered acceptable if it is > 0.5 and very good if it is > 0.7 . Thus, item 21 is excluded and cannot be used to measure students' collaboration skills, while the remaining 20 items are deemed suitable for assessing collaboration skills.

The criteria for confirmatory factor analysis (CFA) include parameters such as RMSEA, RMS, Standard RMR, GFI, and others (Gana & Guillaume Broc, 2019; Hair et al., 2010; Makmee, 2023; Murano et al., 2021). The criteria and results of the CFA analysis for the trial instrument are presented in Table 4. Table 4 indicates that all criteria or parameters, from chi-square (χ^2) to PNFI, for the instrument's collaboration capability have been met, demonstrating that the developed instrument model is valid and fits the model well. The instrument's reliability in this trial is assessed using Cronbach's Alpha and omega, as shown in Table 5.

Table 5
Reliability Results of the Collaboration Skills Instrument

Factor	Coefficient ω	Coefficient α
Work effectively and respect team members	0.752	0.740
Adaptability	0.820	0.817
Responsibility	0.793	0.792
Contribute to the team	0.795	0.753
Total	0.929	0.927
Second Order	0.909	-

Table 5 shows the reliability of each dimension measuring collaboration skills, with omega reliability coefficients ranging from 0.752 to 0.820 and an overall coefficient of 0.929. In comparison, Cronbach's alpha values range from 0.740 to 0.817, with an overall coefficient of 0.927. The reliability coefficient for the CFA second-order model construct of the collaboration capability instrument is 0.909. Based on the estimated reliability results from the trial, it can be concluded that the instrument is proven to be reliable, as it has a reliability coefficient greater than 0.70 (Bahar & Özgürbüz, 2022; Danni et al., 2021; Istiqlal et al., 2024; Shi et al., 2022).

Table 6
Description of Students' Collaboration Skills

	N	Minimum	Maximum	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error
Work effectively and respect team members	750	.00	12.84	6.0125	.10952
Adaptability	750	.00	14.77	8.5801	.12143
Responsibility	750	.00	12.95	6.5770	.11817
Contribute to the team	750	.00	11.87	5.2468	.12082
Total	750	.74	49.42	26.4164	.41793
Valid N (listwise)	750				

Based on Table 6, we can categorise the intervals for each dimension of collaboration skills using values and standard deviations based on the normal distribution. Students' collaboration skills are grouped into three categories: high, medium/moderate, and low, with intervals determined based on the normal distribution. The intervals for each category of collaboration skills in each dimension are presented in Table 7.

Table 7
Interval for Categorizing Participants' Collaboration Skills

Factor	Interval		
	High	Medium	Low
Work effectively and respect team members	$0.83 \leq x$	$3.8 \leq x < 8.3$	$x < 3.8$
Adaptability	$11 \leq x$	$6.1 \leq x < 11$	$x < 6.1$
Responsibility	$9 \leq x$	$4.2 \leq x < 9$	$x < 4.2$
Contribute to the team	$7.7 \leq x$	$2.8 \leq x < 7.7$	$x < 2.8$
Collaboration skills	$34.9 \leq x$	$17.83 \leq x < 34.99$	$x < 17.83$

Table 8*Distribution of Ability to Work Effectively and Respect Team Members*

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Low	209	27.9	27.9	27.9
	Moderate	345	46.0	46.0	73.9
	High	196	26.1	26.1	100.0
	Total	750	100.0	100.0	

Table 8 shows the distribution of students' ability to work effectively and respect team members. Among the participants, 27.9% are categorised as low, 26.1% as high, and 46% as medium, with an overall average score of 6.01. Therefore, students' collaborative skills in working effectively and respecting team members fall into the moderate category. However, these results indicate that 27.9% of students require additional support as their collaborative skills are below average. Practical collaboration skills can be enhanced through project-based learning implementations (Cifrian et al., 2020; Hao et al., 2024). Systematic project work provides students with experiences that promote effective collaboration.

Table 9*Distribution of Students' Adaptability Skills*

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Low	171	22.8	22.8	22.8
	Moderate	364	48.5	48.5	71.3
	High	215	28.7	28.7	100.0
	Total	750	100.0	100.0	

Table 9 shows that the distribution of students' abilities in the adaptability dimension is predominantly characterised by students with medium skills, totalling 364 individuals or 48.5%. The high category includes 215 individuals, or 28.7%, while the low category comprises 171 individuals or 22.8%. Based on these results, it can be concluded that students' collaboration skills in the adaptability dimension are classified as medium. This conclusion is supported by the average (mean) score in the adaptability dimension, which is 8.58, falling within the medium category range of $6.1 \leq x < 11$.

Furthermore, Table 9 reveals that 22.8% of students need improvement or training in their collaboration skills because their abilities are below the average of their peers. Students' adaptation skills can be enhanced through problem-based learning models, (Salim et al., 2023; Lin & Jiang, 2023). Inquiry-based learning emphasises exploration and investigation by the students themselves, encouraging them to ask questions, conduct experiments, find answers, and solve problems independently (Malik et al., 2023). Therefore, problem-based learning models are suitable for developing students' adaptation skills.

Table 10*Distribution of Students' Responsibility Skills*

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Low	186	24.8	24.8	24.8
	Moderate	380	50.7	50.7	75.5
	High	184	24.5	24.5	100.0
	Total	750	100.0	100.0	

Table 10 shows that the distribution of students' responsibility skills is predominantly moderate, with 380 students, or 50.7%, falling into this category. In the high category, there are 184 students, or 24.5%, while 186 students, or 24.8%, are in the low category. Based on these results, it can be concluded that students' collaboration skills in the responsibility dimension are classified as moderate. This conclusion is also supported by the average (mean) score for the responsibility dimension, which is 5.24 and falls within the moderate range of $4.2 \leq x < 9.0$.

Students whose collaboration skills in the responsibility dimension fall below the average of their peers make up 24.8% of the group. This subset may benefit from targeted interventions to enhance their skills. One

approach that teachers can implement is Project-Based Learning (PjBL) (Cifrian et al., 2020). In this method, students are randomly grouped, and each group member is assigned specific responsibilities for working on or completing a given project, distributing tasks and responsibilities evenly among them.

Table 11
Distribution of Students' Contributions to Team Skills

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Low	228	30.4	30.4	30.4
	Moderate	308	41.1	41.1	71.5
	High	214	28.5	28.5	100.0
	Total	750	100.0	100.0	

Table 11 indicates that students' contributions to team skills are classified as moderate, with an average score of 5.24, placing it in the medium category. The table also shows the distribution of collaboration skills within the contribution dimension to the team, predominantly represented by students with moderate abilities—308 students or 41.1%. This is followed by 228 students, or 30.4%, in the low category, and 214 students, or 28.5%, in the high category.

Enhancing collaboration skills in the dimension of team contribution can be achieved by applying 21st-century learning models. In addition to project-based learning and problem-based learning, the discovery learning model can also be used. Discovery Learning is an educational approach where students are encouraged to discover new information or concepts through exploration and investigation independently (Aldalur & Perez, 2023; Belton, 2016; Nicol et al., 2023). This learning model can help students contribute to research or investigate topics provided by the teacher, allowing each group member to construct their knowledge and contribute effectively within the team.

Table 12
Distribution of Students' Collaboration Skills

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Low	196	26.1	26.1	26.1
	Moderate	347	46.3	46.3	72.4
	High	207	27.6	27.6	100.0
	Total	750	100.0	100.0	

Table 12 presents the students' collaboration skills after combining all dimensions. Overall, the students' collaboration skills are classified as moderate, as indicated by the average score of 26.4, which falls within the moderate category. The detailed distribution of collaboration skills among students in Islamic Senior High Schools (Madrasah Aliyah) in the Bangka Belitung Islands Province shows that 347 students (46.3%) are classified as moderately skilled, 207 students (27.6%) as highly skilled, and 196 students (26.1%) as having low skills.

Conclusion

Based on the research findings, it can be concluded that the instrument used to measure students' collaboration skills has been proven valid and reliable. This is supported by the following indicators: a loading factor > 0.5 , T-value > 1.96 , RMSEA $0.00 < 0.08$, RMR $0.043 \leq 0.10$, Std. RMR $0.040 \leq 0.10$, GFI $0.95 \geq 0.90$, AGFI $0.87 \geq 0.80$, NFI $0.90 \geq 0.90$, NNFI $0.97 \geq 0.90$, CFI $0.98 \geq 0.90$, IFI $0.98 \geq 0.90$, RFI $0.97 \geq 0.90$, and a reliability coefficient of 0.909 for the second-order confirmatory factor analysis. The results also indicate that the overall collaboration skills of Islamic Senior High School/Madrasah Aliyah students in the Bangka Belitung Islands Province are categorised as moderate, as reflected by an average score (mean) of 26.4, which falls within the medium range. The detailed distribution shows that 347 students (46.3%) have moderate skills, 207 students (27.6%) have high skills, and 196 students (26.1%) have low skills. Based on these findings, teachers and stakeholders are encouraged to enhance students' collaboration skills through student-centred learning approaches, such as project-based learning, which provides students with opportunities to actively engage in learning and collaborate with peers in completing projects assigned by teachers.

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