

Advancing Collaborative Competence: Instrumentation Development and Integration Strategies for Effective Learning

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Abstract

Collaboration is one of the 21st-century skills that students need to develop, as it underpins further study, participation in society, and entry into the world of work. Teachers therefore need to facilitate and assess students' collaboration skills, which requires a valid, reliable, and effective measurement instrument. This study aimed to develop such an instrument using the 4-D development model (define, design, develop, and disseminate). The define stage revealed that many teachers lacked an instrument for measuring collaboration skills; indicators of the construct were identified accordingly. The design stage produced a collaboration skills instrument comprising nine indicators: contribution, time management, problem-solving, collaboration with others, investigative techniques, quality of work, task focus, readiness, and group-effectiveness monitoring. A scoring rubric was then developed for each indicator. The instrument was validated by experts and tested in two field trials with Grade XI students at two Muhammadiyah senior high schools in Surabaya, Indonesia. Expert validation indicated that the instrument was highly valid, and the trials, conducted using the Inquiry-Based Science Collaboration (IBSC) learning model, showed it to be reliable and effective in measuring collaboration skills. The novelty of this study lies in a collaboration skills instrument shown to be theoretically and empirically suitable for use.

Keywords: collaborative competence, empowering education, instrumentation development, integration strategies



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1. Introduction

Collaboration skills are essential for students to develop because they function as tools in life. Collaborative skills include 21st-century skills demanded in the current global era (Scott, 2015). Collaboration skills are needed when students continue their

studies in the community or work (Arends, 2012). Students must develop collaboration skills (Permendikbud No. 20 of 2016; 21st-century skills). Therefore, in learning, it is essential to help students develop collaboration skills (Care et al, 2015; Scott, 2015). Permendiknas No. 58 of 2014, states

that collaboration skills need to be integrated into learning, including in learning Biology. Collaboration skills are one of the skills that must be trained in the “Kurikulum Merdeka” in Indonesia, as stated in the Minister of Education and Culture Regulation Number 22 of 2022 concerning the Strategic Plan of the Ministry of Education and Culture for 2020-2024.

Through collaboration, an attitude of empathy and concern for others will be built in students (Aini et al., 2020; Vance & Smith, 2019). Through collaboration, students who have low abilities will be able to achieve the expected learning goals because collaboration will involve active participation of students to achieve common goals with high positive dependence (Andrini & Yusro, 2021; Burns, M., Pierson, E., & Reddy, 2014; Jones & Vall, 2014).

Collaboration skills in the context of self-directed learning using the Merdeka Curriculum in Indonesia emphasize students' abilities to collaborate, share ideas, and support each other in achieving learning objectives effectively (Arung et al., 2023). Students are encouraged to actively participate in the learning process, both individually and in groups, utilizing available resources (Muhibbin et al., 2020; Putri et al., 2022). Additionally, the Merdeka Curriculum promotes the development of creativity, innovation, and self-responsibility in learning. Through this approach, students are expected to cultivate their collaborative skills, such as effective communication, leadership, and the ability to work in teams (Khusnani et al., 2023). With a focus on self-directed learning, students are directed to become critical and independent thinkers while still being capable of collaborating with others to achieve optimal learning outcomes in line with the spirit of the Merdeka Curriculum (Aditama et al., 2022).

When a teacher wants to practice collaboration skills, the teacher needs to know about the collaboration skills that students have (Care et al., 2015; Read write think, 2005). Thus, the teacher must be able to measure these skills (Hinyard et al., 2019; Sato, 2011, 2014). An instrument of collaboration is needed. Therefore, this research is fundamental because teachers can use the results of the instruments developed to measure their students' collaboration skills. This study aims to develop instruments to measure students' collaboration skills, providing a novel contribution that aligns both theoretically and empirically (Christidamayani & Kristanto, 2020).

2. Method

The type of research is development research, namely developing instruments to measure collaboration skills. The type of instrument produced is an observation sheet of collaboration skills. This development is based on the 4-D development model (four-D Models) developed by Thyagarajan (Aini et al., 2020). The 4-D development model consists of Defining, Designing, Developing, and Disseminating. However, this research is limited to the development stage.

At the define stage, the authors define collaboration skills and determine indicators of collaboration skills through literature studies. Thus, appropriate indicators are obtained to measure collaboration skills. At the design stage, the authors designed a collaboration skill instrument and determined the score and scoring rubric to be used as a measuring tool (Nieveen & Folmer, 2013). Furthermore, for the developed stage, the authors tested the validity and reliability of the instrument and tested it on students to see its effectiveness in measuring collaboration skills. The research instrument used was a

validation sheet to validate the collaboration skills instrument. Trials on students in learning using the IBSC (Investigation Scientific Collaboration) learning model to see the level of reliability of the instrument, as well as to measure the effectiveness of the instrument in measuring collaboration skills (Suharti et al, 2020). The reason for using the IBSC model to test the collaboration instruments that were being developed is because this learning model facilitates training in collaboration skills. This skill is trained through the second phase, the investigation collaboration sharing task, and the fourth phase, the investigation collaboration jumping task. In these two phases, teachers are asked to act as facilitators to facilitate cooperation between students by fostering positive dependence between students according to the learning steps in these two phases.

The instrument to be used must be declared fit to implement it. Feasibility is determined based on the results of the instrument validity test. Meanwhile, the instrument's effectiveness is measured based on the results of trials on students in classroom learning using the IBSC model. The effectiveness is seen based on the T-test results, which state a significant difference between the initial (pretest) and final (posttest) collaboration scores. Next, the average n-Gain value is looked at to determine the effectiveness of the increase. The criteria consist of less effective (the average n-Gain is less than 30), quite effective (average n-Gain between 30-70), and very effective (average n-Gain value more than 70). Trials were conducted twice at SMAM 7 Surabaya (2 classes) and SMAM 3 Surabaya (3 classes) in class XI.

3. Result and Discussion

Researchers adapted opinions from the International Reading Association (Read

write thing, 2005) and (Care et al., 2015) to assess collaborative skills from the definition results. Collaboration skills are identified based on aspects/indicators: 1) contribution, 2) time management, 3) problem solving, 4) working with others (Working with others), 5) research techniques 6) quality in work, 7) focus on the task, 9) preparedness and 10) monitoring group effectiveness.

At the design stage, each indicator's score is determined. Each indicator is assigned a score of 1 to 4 with different statements (Read write think 2005 and Griffin et al, (2012). Here is one aspect: the contribution is divided into four statements with a score of 1 to 4 from the standard rubric of ability to collaborate (Read write think 2005 and Griffin et al, (2012).

As an example of an assessment for the Working with other indicator below.

The 1st statement is given a score of 1:

"Rarely listens to, shares with, and supports the efforts of others. Often he is not a good team player."

The 2nd statement is given a score of 2:

"Often listens to, shares with, and supports the efforts of others, but sometimes it's not a good team member."

The 3rd statement is given a score of 3:

"Usually listens to, shares with, and supports the efforts of others. Does not cause "waves" in the group."

The 4th statement is given a score of 4:

"Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together."

Based on these two standard rubrics, a rubric is then made to measure the adapted collaboration skills, as shown in Table 1.

Table 1. Collaboration Skills Rubric Design

Indicators	Score			
	1	2	3	4
Contribution	In large or small group discussions, do not give ideas and do not participate.	In large or small group discussions, only one idea is given once, and only one time contributed in participating.	In large or small group discussions, ideas are only given two times. And not often (only two times) contributed in participating.	In large or small group discussions, they often (more than 2 times) give ideas that become a reference in the discussion. Able to lead discussions and often (more than 2 times) contribute to participation
Time management	Not doing the assignment caused the group to extend the time limit for its work..	The task was completed but was late > 3 minutes from the specified time. This caused the group to extend the time limit for its work.	Tasks completed but late < 3 minutes from the specified time. So it doesn't cause the group to extend the deadline for its work.	Complete tasks on time or finish before the deadline so that it never causes the group to extend the deadline for its work.
Problem-solving	There is no effort to find and answer problems and give all tasks to others.	Rarely (only once) tried to find answers to problems and use solutions initiated by others.	Often (only two times), people try to find answers to problems, but the solutions found result from the development from other people's ideas.	Very often (more than two times), make an apparent effort to find and provide own ideas for answers.
Working with others	Not listening to other people's opinions or not helping others and not participating in group work.	Rarely (only once) listens to other people's opinions and rarely (only once) helps others due to difficulties in group work.	Often (only 2 times) listens to other people's opinions and often (only 2 times) helps others, but does not make it easier in group work.	Very often (more than 2 times) listens to other people's opinions well and very often (more than 2 times) helps others, making it easier to work in groups.
Research techniques	Provide work that would normally need to be inspected or repaired by someone else to ensure quality	Rarely seeks multiple sources (only focuses on 2 sources) and records information, but not detail	Often searches for various sources (only focused on 3 sources) and always records information, but not in detail	Very Often searches for multiple sources (focused on more than 3 sources) and always records information in detail
Quality in Work	Does not seek multiple sources (focusing on only one source) and does not record information.	Provide work that occasionally needs to be checked or corrected by other group members to ensure quality	Delivering good quality work	Doing work of the highest quality

Indicators	Score			
	1	2	3	4
Focus on the Task	Rarely focuses on tasks and what needs to be done. Enabling others to do the work Focusing on the task and what needs to be done.	Other group members sometimes have to grumble, insist, remind this person to stay on duty.	Focus on tasks and what needs to be done most of the time. Other group members can count on this person.	Consistently stay focused on the task and what needs to be done. very independent,
Preparedness and	Often forgets materials/materials needed or rarely ready to start work	Almost always has the materials needed with him but occasionally needs to calm down and get to work	Almost always brings the materials needed to class and ready to work	Bring the materials needed to class and always ready to work
Monitoring group effectiveness	Rarely monitors group effectiveness and doesn't work to make it more effective	Occasionally monitors group effectiveness and works to make the group more effective	Regularly monitor group effectiveness and work to make the group more effective	Regularly monitor group effectiveness, and make suggestions to make it more effective

Adapted from IRA (Read write think, 2005) and (Care et al., 2015)

The collaboration skills observation sheet instrument is valid and reliable and is quite effective in measuring collaboration skills. This is based on the mode of the average value of all aspects of the validity of the collaboration skills instrument from the results of the assessment of 3 validators with an average mode score of 4, which means it

1. Results of Trial I Collaboration Skills in Learning

To see the effectiveness of the collaboration instrument developed, a trial I was carried

out in learning at SMAM 7 Surabaya using the IBSC model. The data on the completeness of the collaboration skills from the results of the first trial are presented in Table 2.

Table 2. Proportion of Pree Test and Posttest Completeness on Student Collaboration Skills in Trial I

No Subject	Pre Test	Posttest	n-Gain Skor (%)
1	44.45	88.89	80.00
2	44.45	88.89	80.00
3	44.45	77.76	58.96
4	77.76	100.00	100.00
5	44.45	77.76	59.96
6	22.23	88.89	85.71
7	22.23	77.76	71.43
8	22.23	66.67	57.14
Total	322.25	666.55	584.8

No Subject	Pre Test	Posttest	n-Gain Skor (%)
Average	40.28	83.32	73.1

Based on Table 2, it can be seen that the entire proportion of completion of the collaboration skills pretest results is below the minimum completeness category, namely 75% and the average mastery of student collaboration skills is 40.28. This shows that no students have a complete category in student collaboration skills that are measured at the beginning. While the proportion of mastery of final collaboration skills/posttest, students with a proportion of post test more than 75% in trials I, is 87.5 % and the average mastery of student collaboration skills is 83.32, above the minimum mastery category of 75%.

To strengthen the effectiveness of the instrument in measuring student collabora-

tion skills in learning using the IBSC learning model, a statistical test was carried out using the t-test on the data on the proportion of mastery of pretest and posttest of student collaboration skills and N-Gain analysis (Table 2). Previously the data was tested for distribution with the Kolmogorov test. Based on the Kolmogorov test results, the data is stated to be normally distributed because a significance value of $0.200 > 0.05$ is obtained. Furthermore, the initial data/results of the pretest and posttest were tested using the t-test. The results of the t-test are shown in Table 3.

Table 3. Paired Samples Test

Pair	Measured Variables	Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-3.75000	1.38873	.49099	-4.91101	-2.58899	-7.638	7	.000

The results of the t-test showed a significance value of $0.000 < 0.05$, which means that there was a significant difference between the proportions of pretest and post-

test of students' collaboration skills in the trial class I. Next, we looked at the correlation between the pretest and posttest results.

Table 4. Paired Samples Correlations of Trial I

Pair	Measured Variables	N	Correlation	Sig.
Pair 1	Pretest & Posttest	8	.616	.104

The results of the correlation test between the pretest and posttest of student's Collaboration skill mastery proportion values in class trial I, showed no correlation between the pretest and posttest Collaboration skill mastery proportion values, because the significance value of the correlation between the two was $0.104 > 0.05$. (Table 4)

The results of the class I trial n-Gain analysis are shown in Table 4. Based on the analysis of the Tryout class's n-Gain value, I obtained an average n-Gain value of 73.1 %. This shows that the collaboration instrument is quite effective in measuring collaboration skills in learning using the IBSC learning model

2. Results of Trial II Collaboration Skills in Learning

To further examine the empirical quality of the developed collaboration skills instrument, a second trial was conducted involving three replication classes at SMAM 3 Surabaya using the Investigation Based Scientific Collaboration (IBSC) learning model. This stage was intended to evaluate the consistency and reliability of the instrument when applied across different classroom settings and student groups. In addition to confirming

the findings obtained in Trial I, the second trial provided broader empirical evidence regarding the instrument's capability to measure students' collaboration skills accurately. The analysis included comparisons of pretest and posttest scores, paired sample statistical tests, correlation analysis, and n-Gain calculations to determine the effectiveness of the instrument in assessing improvements in collaboration skills across the three replication classes.

Table 5. Proportion of Pree Test and Posttest Completeness on Student Collaboration Skills in Trial 2

No subject	Replication 1 (IPA 1)		Replication 2 (IPA 2)		Replication 3 (IPA 3)	
	Pre	Post	Pre	Post	Pre	Post
1	55.57	77.79	11.12	88.90	66.68	100
2	33.34	77.79	22.23	77.78	44.45	88.90
3	33.34	77.79	44.45	66.67	66.68	100
4	33.34	66.68	55.57	66.67	55.57	77.78
5	22.23	55.57	11.13	55.57	33.34	77.78
6	22.23	88.90	33.34	66.68	33.34	77.78
7	33.34	88.90	33.34	77.79	33.34	88.89
8	22.23	66.68	44.45	77.79	33.34	77.78
9	22.23	66.68	44.45	66.68	44.45	66.68
10	33.34	66.68	44.45	77.79		
Total	311.18	733.46	344.52	722.75	422.27	755.55
Average	31.1	73.4	34.5	72.3	46.9	83.9

Based on Table 6, there is an increase in the mastery of collaboration skills in students in trial II in the three replication classes. To strengthen the instrument's effectiveness in measuring student collaboration skills, measurements were taken in learning using the IBSC learning model. Then a t-test was carried out on the data on the proportion of mastery of pree test and pos test of students' collaboration skills and n-Gain analysis. Previously, The pretest and posttest data on student collaboration skills in the three classes were tested for homogeneity of variance.

Based on Table 2, it can be seen that the entire proportion of completion of the collaboration skills pretest results is under the minimum completeness category, namely

75% and the average mastery of student collaboration skills is 40.28. The results of the variance homogeneity test stated that the three classes were homogeneous because the significance value was $0.302 > 0.05$. Likewise, with the homogeneity test results, the posttest data's value is homogeneous. This shows that the instrument is empirically reliable in measuring collaboration skills.

The data normality test results for each trial II replication class have normal data distribution because the significance values obtained successively in replication classes I, II, and III are 0.133, 0.178, 0.71, which are all > 0.05 . The t-test is then carried out. The t-test results for each replication are shown in Tables 6, 8, and 10.

a. T Test Results in Class of Replication I of Trial II (XI IPA 1)

Before conducting the paired sample t-test, the pretest and posttest data obtained from Replication Class I (XI IPA 1) in Trial II were examined to ensure that the assumptions required for parametric statistical analysis had been satisfied. The normality test confirmed that the data were normally distributed, indicating that the paired sample t-test was appropriate for comparing stu-

dents' collaboration skill scores before and after the implementation of the IBSC learning model. This analysis was performed to determine whether the observed improvement in collaboration skills was statistically significant and to provide empirical evidence regarding the effectiveness of the developed collaboration assessment instrument in measuring changes in students' collaborative competence.

Table 6. Paired Samples Test

Pair	Measured Variables	Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest – Posttest	-3.80000	1.39841	.44222	-4.80036	-2.79964	-8.593	9	.000

Based on the paired sample t-test results presented in Table 6, the mean difference between the pretest and posttest scores was -3.80 , indicating that students' collaboration skill scores after the implementation of the IBSC learning model were higher than their initial scores. The 95% confidence interval of the mean difference ranged from -4.80036 to -2.79964 , which did not include zero, further confirming the existence of a statistically significant difference between

the two measurements. In addition, the obtained t-value of -8.593 with 9 degrees of freedom and a significance value of 0.000 ($p < 0.05$) demonstrates that the improvement in students' collaboration skills was statistically significant. These findings indicate that the developed collaboration assessment instrument was sensitive in detecting changes in students' collaborative competence following the learning intervention implemented through the IBSC learning model.

Table 7. Paired sample correlations of class replication I of trial II

Pair	Measured Variables	N	Correlation	Sig.
Pair 1	Pretest & Posttest	10	-.100	.783

The results of the correlation test between the values of the proportion of mastery of collaboration skills for trial II in class of replication I, showed that there was no correlation between the values of the proportion of mastery of pre test and post test of student's collaboration skills, because the significance value of the correlation between the two was $0.78 > 0.05$

a. T-Test Result in Class of Reflication II Trial II (XI IPA 2)

Following the completion of the assumption tests, the pretest and posttest scores obtained from Replication Class II (XI IPA 2) in Trial II were analyzed using a paired sample t-test to determine whether the implementation of the IBSC learning model resulted in a statistically significant impro-

vement in students' collaboration skills. The normality test confirmed that the data satisfied the assumptions required for parametric analysis, allowing further statistical evaluation using the paired sample t-test. This analysis was conducted to compare students'

collaboration skill achievement before and after the learning intervention and to provide additional empirical evidence regarding the effectiveness and consistency of the developed collaboration assessment instrument across different replication classes.

Table 8. Paired Samples Test

Pair	Measured Variables	Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest – Posttest	-3.40000	1.71270	.54160	-4.62519	-2.17481	-6.278	9	.000

Based on the paired sample t-test results presented in Table 8, the mean difference between the pretest and posttest collaboration skill scores was -3.40 , indicating a substantial improvement in students' collaboration skills following the implementation of the IBSC learning model. The 95% confidence interval, ranging from -4.62519 to -2.17481 , did not include zero, confirming that the observed difference was statistically reliable. Furthermore, the analysis yielded a

t-value of -6.278 with 9 degrees of freedom and a significance value of 0.000 ($p < 0.05$), demonstrating that the increase in collaboration skills was statistically significant. These findings provide additional empirical evidence that the developed collaboration assessment instrument was capable of consistently detecting improvements in students' collaborative competence across different replication classes after the learning intervention.

Table 9. Paired Samples Correlations in Class of Reflication II of Trial II

Pair	Measured Variables	N	Correlation	Sig.
Pair 1	Pretest & Posttest	10	-.143	.693

The results of the correlation test between the values of the proportion of mastery collaboration skills in trial II in replication class II showed that there was no correlation between the values of the proportions of the pretest and posttest collaboration skills mastery, because the significance value of the correlation between the two was $0.259 > 0.05$.

b. T Test Result in Class of Reflication III of Trial II (XI IPA 3)

To complete the empirical evaluation of the developed collaboration assessment ins-

trument, the pretest and posttest scores from Replication Class III (XI IPA 3) in Trial II were analyzed using a paired sample t-test. Prior to hypothesis testing, the data were confirmed to meet the normality assumption, ensuring the appropriateness of applying parametric statistical analysis. The paired sample t-test was conducted to determine whether students' collaboration skills improved significantly following the implementation of the IBSC learning model. The results obtained from this replication class were expected to provide additional evidence regarding the robustness, consistency, and ef-

fectiveness of the developed instrument in measuring changes in students' collaborative competence across different classroom contexts.

Table 10. Paired Samples Test

Pair	Measured Variables	Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest – Posttest	-3.33333	1.00000	.33333	-4.10200	-2.56467	-10.000	8	.000

The results of the t test in class of replication III trial II, obtained a significance value of $0.000 < 0.05$, which means that there was a significant difference between the proportion of pre test and pos test of students' collaboration skills in trial II, class of replication III. To see the effectiveness of improving students' collaboration skills as a result of the trial, an n-Gain test was. To see the effectiveness of improving students' collaboration skills as a result of the trial, an n-Gain test was conducted

c. Analysis of n-Gain Value in Class of Replication I of Trial II (XI IPA 1)

Following the confirmation of a statistically significant difference between the pre-

test and posttest scores through the paired sample t-test, an n-Gain analysis was conducted to determine the magnitude of improvement in students' collaboration skills after the implementation of the IBSC learning model. While the t-test indicates whether the observed improvement is statistically significant, the n-Gain analysis provides additional information regarding the effectiveness of the learning intervention by quantifying the level of learning improvement achieved by students. The descriptive statistics of the n-Gain scores in Replication Class I (XI IPA 1) are presented in Table 11, providing a comprehensive overview of students' learning gains and the effectiveness of the developed collaboration assessment instrument.

Table 11. Result Description n-Gain

Variable	Statistic		Statistic	Std. Error
N_Gain_Skor	Mean		60.2370	5.20478
	95% Confidence Interval for Mean	Lower Bound	48.4630	
		Upper Bound	72.0110	
	5% Trimmed Mean		60.3167	
	Median		57.1400	
	Variance		270.897	
	Std. Deviation		16.45895	
	Minimum		33.33	
	Maximum		85.71	
	Range		52.38	
	Interquartile Range		21.43	
	Skewness		.337	.687
	Kurtosis		-.167	1.334

The analysis results of the n-Gain value analysis in the class of replication II trial I obtained an average n-Gain value of 60.24. This shows that the collaboration Instrument is quite effective in measuring collaboration skills in learning by using the IBSC learning model in trial II class of replication I.

d. Analysis of n-Gain Value in Class of Replication II of Trial II (XI IPA 2)

To further evaluate the effectiveness of the learning intervention in Replication Class II (XI IPA 2), an n-Gain analysis was performed after the paired sample t-test had

confirmed a statistically significant difference between the pretest and posttest scores. The n-Gain analysis was intended to quantify the extent of students' improvement in collaboration skills by comparing their initial and final performance. In addition to measuring learning gains, this analysis provided supporting evidence regarding the practical effectiveness of the IBSC learning model and the consistency of the developed collaboration assessment instrument when implemented in different classroom settings. The descriptive statistical results of the n-Gain scores are presented in Table 12.

Table 12. Result Description N-Gain in Replication Class II

Variable	Statistic		Statistic	Std. Error
N_Gain_Skor	Mean		56,0000	5.68853
	95% Confidence Interval for Mean	Lower Bound	42.1916	
		Upper Bound	67.9284	
	5% Trimmed Mean		54.9278	
	Median		55.0000	
	Variance		323.594	
	Std. Deviation		17.98872	
	Minimum		25.00	
	Maximum		87.50	
	Range		62.50	
	Interquartile Range		27.86	
	Skewness		.145	.687
	Kurtosis		.078	1.334

The analysis of the n-Gain value in the Trial II class of replication II obtained an average N-Gain value of 56%. This shows that the collaboration instrument is quite effective in measuring collaboration skills in learning using the IBSC learning model in the trisl II, class of replication II.

e. Analysis of n-Gain Value in Class of Replication III of Trial II (XI IPA 3)

Following the statistical confirmation of significant differences between the pretest and posttest scores in Replication Class III (XI IPA 3), an n-Gain analysis was conducted to determine the magnitude of students'

improvement in collaboration skills after participating in learning activities based on the IBSC learning model. This analysis complements the findings of the paired sample t-test by providing quantitative evidence of the effectiveness of the learning intervention in enhancing students' collaborative competence. Furthermore, the n-Gain analysis serves to verify the consistency of the developed collaboration assessment instrument across different replication classes. The descriptive statistics of the n-Gain scores obtained from Replication Class III are presented in Table 13.

Table 13. Result Description n-Gain in Replication Class III

Variable	Statistic		Statistic	Std. Error
N_Gain_Skor	Mean		71.8522	6.94121
	95% Confidence Interval for Mean	Lower Bound	55.8458	
		Upper Bound	87.8587	
	5% Trimmed Mean		72.0580	
	Median		66.6700	
	Variance		433.624	
	Std. Deviation		20.82363	
	Minimum		40.00	
	Maximum		100.00	
	Range		60.00	
	Interquartile Range		36.67	
	Skewness		.035	.717
	Kurtosis		-.931	1.400

The analysis of the n-Gain value in the Trial II of class replication III obtained an average n-Gain value of 71.85 %. This shows that the collaboration instrument is quite effective in measuring collaboration skills in learning using the IBSC learning model in the trial II, class replication III.

by Anova, to see the difference in the impact of applying the IBSC learning model, the results are shown in table 14. Furthermore, the n-Gain data of class replication I, II and II in trial II were tested.

Tabel 14. ANOVA Test Results

N_Gain	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1386.221	2	693.111	2.043	.150
Within Groups	8819.410	26	339.208		
Total	10205.632	28			

The results of the ANOVA test obtained a significance value of $0.150 > 0.05$, this indicates that the IBSC model has the same impact on improving student collaboration skills.

Based on data on the proportion of mastery of pre-test collaboration skills in the trial class, I showed that all proportions of mastery of student collaboration skills were below the minimum mastery criterion of 75% with the average mastery of student collaboration skills of 40.27. This means that there are no students who have completed the criteria for collaboration skills to be

measured. Based on the data on the proportion of posttest completeness and the collaboration skills of the students in the trial, I showed that the number of students who had completed it was 87.5% (7 of the 10 students observed). Class completeness is more than 80%, with the average posttest mastery of student collaboration skills being 83.31. Indicators that have not reached mastery class 80% of all students observed are indicators 2 (71.4%) and 9 (1.25%).

The results of the data representation of collaboration skills in trial I in the form of graphs as shown in Figure 1.

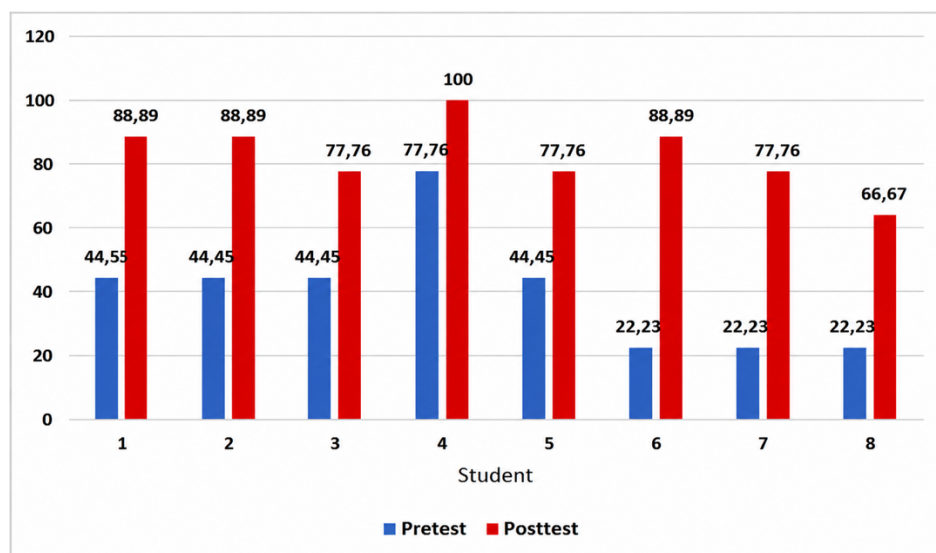


Figure 1. Graph of the Pretest and Posttest Collaboration Skill Mastery of the Students in the Trial I

The results of statistical tests using the t-test on the proportion of mastery of pretest and posttest of student collaboration skills (Table 3) obtained a significance value of $0.000 < 0.05$, which means that there is a significant difference between the proportion of pretest and posttest mastery of student collaboration skills. There is no correlation between the value of the proportion of mastery of pretest and posttest of student collaboration skills because it was found that the significance value of the correlation between the two was $0.104 > 0.05$ (Table 4). The results of the n-Gain analysis of the trial class I (Table 5) obtained an average N-Gain value of 73.1%. This shows that the IBSC learning model fairly effectively influences students' collaboration skills in trial I.

The proportion of mastery of pretest collaboration skills in replication classes I, II, and III trial III (Table 6) shows that all proportions of pretest of student collaboration skills in replication classes I, II, and III are

under the minimum criteria of 75% and the average mastery of student collaboration skills in class of replication I, II and III respectively were 31.1; 34.42 and 42.22 %. This means that no students completed the communication skill criteria measured at the beginning for replication classes I, II, or III.

The proportion of the posttest of students' collaboration skills in replication class I of trial II, which has been completed is 50% of the number of students observed. This means that the mastery of the class is less than 80%, with an average mastery of student collaboration skills of 73.4%. Indicators that did not reached class mastery 80% of all students observed are indicator 2 (30%) indicator 6 (30%) and indicator 9 (1.25%). The results of data representation of collaboration skills in replication class I trial II in the form of bar graphs as shown in Figure 2.

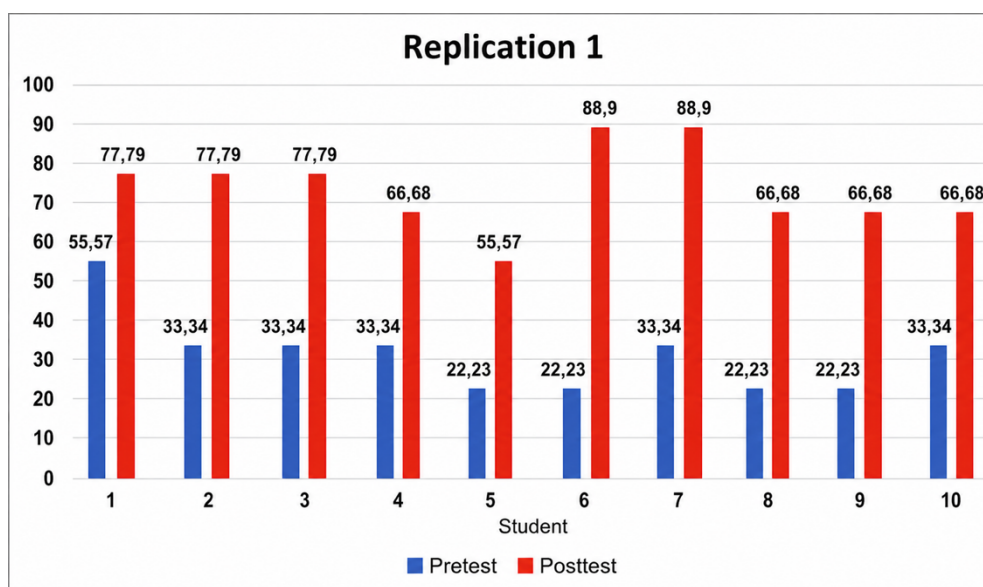


Figure 2. Graph of Pretest and Post Test Collaboration Skill Mastery of Students in Class of Replication 1, Trial II

The proportion of the posttest of students' collaboration skills in class replication II trial II shows the number of students who have completed 50% of the number of students observed. This means that the mastery of the class is less than 80%, with an average mastery of student collaboration skills of 72.3%. Indicators that did not reach class

mastery in 80% of all students observed are indicator 2 (30%), indicator 6 (40%), and indicator 9 (1.25 %).

The results of data representation of collaboration skills in class of replication II, of trial II in the form of graphs as shown in Figure 3.

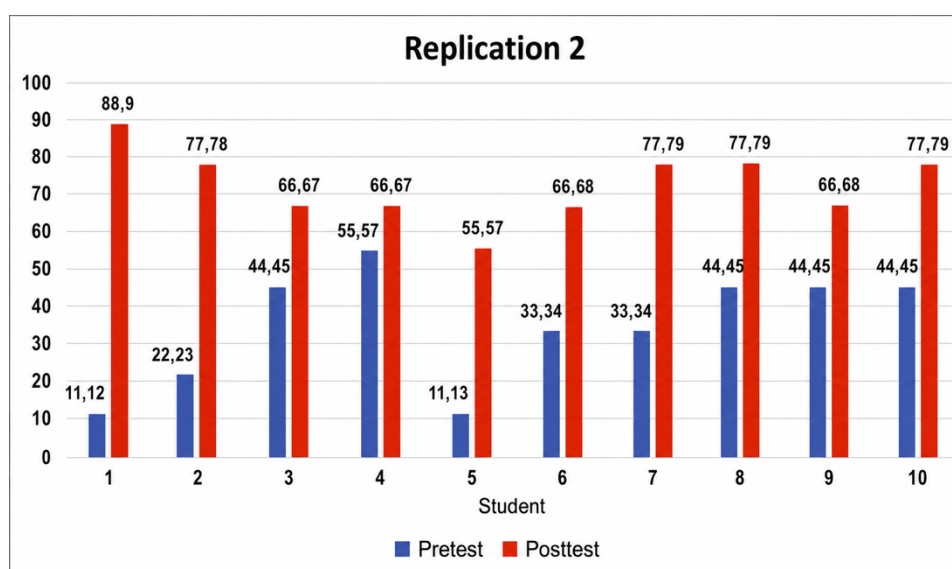


Figure 3. Graph of Pre Test and Post Test Collaboration Skill Mastery of Students in Class of Replication II, Trial II

The proportion of the posttest of the collaboration skills of students in class of repli-

cation III, trial II showed that the number of students who had completed was 88.9 % of

the number of students observed. This means that the mastery of the class is more than 80%, with an average mastery of student collaboration skills of 83%. Indicators that have not reached mastery class 80% of all students observed are indicator 6 (55.6%) and indicator 9 (22.2%)

The results of data representation of collaboration skills in class of replication III of trial II in the form of bar graphs as shown in Figure 4.

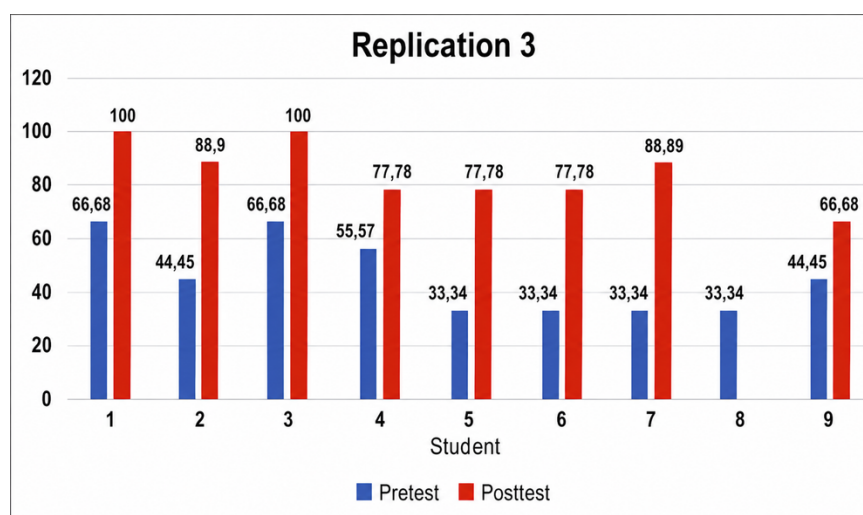


Figure 4. Graph of Pre Test and Post Test Collaboration Skill of Students in Class of Replication III, Trial II

The results of the T-test analysis for replication classes I, II and III in trial II (Table 2; Table 3 and Table 4) in each replication class obtained a significance value of $0.000 < 0.05$. This means there is a significant difference between the proportion of pretest and posttest of the collaboration skills of students of replication class I, II and III in trial II. Based on the results of the correlation test between the values of the proportion of mastery of collaboration skills in the trial II in class of replication I, II and III, it shows that there is no correlation between the values of the proportion of mastery of Collaboration skills at the beginning and at the end (Table 8; Table 10 and Table 12). This shows that the increase in the proportion of mastery of collaboration skills in replication classes I, II, and III is not parallel.

Based on the analysis of the n-Gain values in Trial II of replication classes I, II

and III, the average n-Gain values in repeat classes I, II and III were 60.24% each; 56%; 71.85%. This shows that the value of students' skills increases quite effectively after they are trained in learning through the IBSC model. This means that the IBSC learning model can help students develop collaboration skills (Abdulrazzaq, 2022; Maharani et al., 2021)

The IBSC (Investigation Scientific Based Collaborative) learning model can train student collaboration because in the IBSC learning model there are sharing task collaborative investigation activities and jumping task joint investigations (Supriyanto et al., 2022). These two phases of learning activities are scientific collaborative investigation activities to solve problems (Suharti et al, 2020)—characteristics of the problems that will be resolved in stages, starting from academic issues to authentic

problems. Through sharing tasks and jumping tasks, students must collaborate in solving problems (Sato, 2014). For collaboration between students, the teacher facilitates positive dependence between students. The teacher acts as a facilitator and guide when students work in groups by fostering a sense of empathy in students with high abilities towards students with low skills, and fostering courage in students with low abilities to ask for help from students with high abilities, so that communication and collaboration occurs between students (Blau et al, 2020; Moreno, 2010; OEDC, 2013). In this way, learning interactions occur through communication and collaboration between students when solving problems (Hidayati et al, 2020; Santoso et al., 2021; Zubaidah, 2016).

The results of the Anova test to see the difference in the assessment of collaboration skills in the three classes of replication in trials II based on the n-Gain value, obtained a significance value of $0.15 > 0.05$ (Table 14). This shows that the collaborative observation sheet instrument developed is reliable. Therefore, it is appropriate to be used to assess students' collaboration skills.

4. Conclusion

The collaboration instrument developed consists of 9 indicators: Time management, Problem-solving, Working with others, Research techniques, quality of work, Focus on the task, Preparedness, and Monitoring group effectiveness. For measurement, each indicator is given a score of 1-4. The collaboration instrument was declared valid and reliable. The results of empirical trials show that collaboration in the instrument effectively measures collaboration skills after training using the IBSC learning model. The IBSC learning model can be used to train student collaboration, which is measured

using a collaboration instrument developed because it has a learning phase that asks the teacher to facilitate positive student dependency. As a result, collaboration occurs. The validity and reliability of the collaboration skills instrument show that it is feasible to measure collaboration skills anywhere, anytime, and by anyone who wants to measure them.

5. Authors Contribution

Conceptualization: Peni Suharti, Yusuf Zakaria; **Methodology:** Peni Suharti, Lina Listiana, Emese Kovácsné Nagy; **Investigation:** Peni Suharti, Lina Listiana, Ruspeni Daesusi, Rita Rahmaniati; **Data Curation:** Peni Suharti, Lina Listiana; **Formal Analysis:** Peni Suharti, Ruspeni Daesusi, Sri Sutarni, Yusuf Zakaria; **Validation:** Sri Sutarni, Rita Rahmaniati; **Supervision:** Emese Kovácsné Nagy; **Writing – Original Draft:** Peni Suharti, Lina Listiana; **Writing – Review & Editing:** Ruspeni Daesusi, Sri Sutarni, Rita Rahmaniati, Yusuf Zakaria, Emese Kovácsné Nagy.

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