

A Study on the Correlation of 21st-Century Skills Through a STEM Approach

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ABSTRACT

This study aims to examine the correlation between the development of 21st-century skills in SMA Bintang Madani Omni students. Twenty-one tenth-grade students participated in physics learning on renewable energy using the STEM approach. Students created wind and microhydro power plant projects. Each student assessed each other's 21st-century skills in their group during the four-week learning process. Correlation analysis of each aspect, including collaboration, character (contribution), communication, creativity, and problem-solving, was conducted using the bivariate correlation method on SPSS. After the correlation analysis of 21st-century skills was conducted, students learned about global warming. An inquiry approach was used during global warming learning. Each student assessed their classmates' presentations on each aspect of the 21st-century skills mentioned above. The strongest correlations were found in the collaboration-problem-solving, creativity-collaboration, and character (contribution)-collaboration aspects. Collaboration skills are an important point that has a strong correlation with the aspects of creativity, contribution, and problem-solving. The average score development of 21st-century skills aspects from the STEM approach (renewable energy topic) to the inquiry approach (global warming topic) was positive for 11 students. There were 10 students who experienced a decrease in 21st-century skills scores. This can be a trigger of problem formulation for further research. The results of this study are expected to be material for educators' reflection when applying the STEM approach in the classroom.

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Introduction

21st-century skills are essential for every student. School instruction is expected to develop these skills, equipping students to face the challenges of today and the future. The variety of teaching methods used will determine whether the instruction effectively develops all aspects of 21st-century skills. If the instruction is deemed effective in developing these skills, how significant is its impact on improving students' skills?

One constructivist learning approach is STEM (science, technology, engineering, and mathematics). This approach integrates four content areas: science, technology, design practices, and mathematics. One of the goals of applying STEM in learning is to hone students' 21st-century skills. There are several stages of STEM learning, one of which is the six-step STEM Project-Based Learning (PjBL) framework proposed by Jolly (2017). These six steps include: (1) defining the problem, (2) designing the project plan, (3) creating a

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schedule, (4) monitoring project progress, (5) testing the results, and (6) evaluating the learning experience.

The STEM approach can be applied to hone students' 21st-century skills. However, evaluations of this STEM approach often focus on the success of students' products (work). In fact, as part of the learning process, evaluation should also assess the behavioral changes demonstrated by students during the implementation of this approach. The 21st-century skills expected to develop in students through the implementation of the Merdeka curriculum include: communication skills, creativity, critical thinking, and improved collaboration skills [1].

If the STEM approach is considered capable of honing 21st-century skills, then which specific aspects of 21st-century skills are most affected? Furthermore, how do these aspects of 21st-century skills influence one another? It is necessary to measure and analyze the aspects of 21st-century skills that are utilized during STEM-based learning.

Physics is a subject closely related to the STEM approach. Physics content should be presented in the form of problem-solving projects that can hone students' critical thinking skills [2]. For example, topics such as renewable energy and global warming can serve as catalysts for STEM projects that can be implemented in the classroom.

The purpose of this study is to measure the correlation among various aspects of 21st-century skills and to determine the significance of the influence of one aspect of 21st-century skills on the others. The results of this analysis are expected to serve as a basis for educators' reflection when applying the STEM approach in the classroom.

Method

This study is quasi-experimental in nature. The researcher is a physics teacher who implemented the intervention in the classroom. The group of students involved in this study consists of 10th-grade students at Bintang Madani Omni High School during the 2025–2026 school year. Data collection took place from September to October 2025 and in January 2026.

In Phase 1, which took place from September to October 2025, students were divided into four groups to work on a STEM project to build hydroelectric and wind power plants. While working on the devices, students observed the performance of their group members. After the presentations, students graded their group members. The researcher, who also serves as a teacher, acts as a facilitator when students encounter obstacles during the project. The ratings given by students to their group members consist of five criteria: (1) collaboration; (2) empathy, hard work, and tolerance; (3) creativity; (4) communication; and (5) problem-solving and critical thinking. The rating scale for these five aspects ranges from 1 (poor), 2 (fair), 3 (good), to 4 (very good).

In Phase 2, in January 2026, students were asked to analyze an article on the impacts of global warming. Each student took turns presenting the article to their classmates. Afterward, classmates assigned scores to the presenters. The assessment criteria for Phase 2 consist of four points, namely: (1) Critical thinking; (2) Communication; (3) Creativity; (4) Problem-solving. The rating scale for these five aspects ranges from 1 (poor), 2 (fair), 3 (good), to 4 (very good).

Results and Discussion

Student profiles were categorized by gender and junior high school (SMP) of origin. The average scores for each measured 21st-century skill are listed in Table 1. The highest

average score for the collaboration skill was achieved by female students from Bintang Madani Junior High School. In the character aspect, the highest average score was found among female students from SMP Bintang Madani. In contrast to the previous two aspects, the highest scores for creativity, communication, and problem-solving were found among male students from SMP Bintang Madani.

Table 1: Descriptive Analysis of 21st-Century Skills

	Gender	Sekolah	Mean	Std. Deviation	N
Collaboration	Girls	SMP BM	3.7000	.41079	5
		SMP Non BM	3.2500	.25000	3
		Total	3.5313	.41052	8
	Boys	SMP BM	3.6833	.38837	3
		SMP Non BM	3.3600	.18227	10
		Total	3.4346	.26488	13
	Total	SMP BM	3.6938	.37363	8
		SMP Non BM	3.3346	.19406	13
		Total	3.4714	.32155	21
Character	Girls	SMP BM	3.6500	.51841	5
		SMP Non BM	3.3333	.38188	3
		Total	3.5313	.47127	8
	Boys	SMP BM	3.5333	.50332	3
		SMP Non BM	3.4650	.33752	10
		Total	3.4808	.35855	13
	Total	SMP BM	3.6062	.47916	8
		SMP Non BM	3.4346	.33627	13
		Total	3.5000	.39433	21
Creative	Girls	SMP BM	3.4500	.32596	5
		SMP Non BM	3.2500	.25000	3
		Total	3.3750	.29881	8

	Boys	SMP BM	3.6000	.30414	3
		SMP Non BM	3.1400	.66658	10
		Total	3.2462	.62399	13
	Total	SMP BM	3.5063	.30524	8
		SMP Non BM	3.1654	.58821	13
		Total	3.2952	.51863	21
Communication	Girls	SMP BM	3.3000	.32596	5
		SMP Non BM	3.1667	.14434	3
		Total	3.2500	.26726	8
	Boys	SMP BM	3.7833	.20207	3
		SMP Non BM	3.3750	.39878	10
		Total	3.4692	.39767	13
	Total	SMP BM	3.4813	.36736	8
		SMP Non BM	3.3269	.36206	13
		Total	3.3857	.36302	21
Problemsolving	Girls	SMP BM	3.2500	.25000	5
		SMP Non BM	3.0000	.25000	3
		Total	3.1563	.26517	8
	Boys	SMP BM	3.3000	.26458	3
		SMP Non BM	3.2900	.26541	10
		Total	3.2923	.25401	13
	Total	SMP BM	3.2688	.23745	8
		SMP Non BM	3.2231	.28182	13
		Total	3.2405	.26059	21

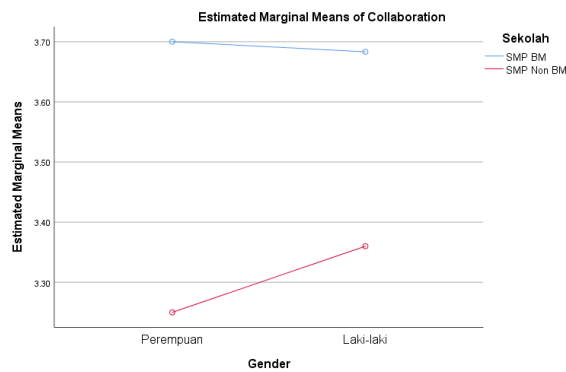


Figure 1: Comparison of Average Scores for the Collaboration Aspect Chart

The average score for the collaboration aspect among students from Bintang Madani Junior High School was higher than that of students from junior high schools other than Bintang Madani. Interestingly, the average score for the collaboration aspect among female students from Bintang Madani Junior High School was higher than that of male students from the same school. In contrast to students from Bintang Madani Junior High School, male students at other schools scored higher than female students.

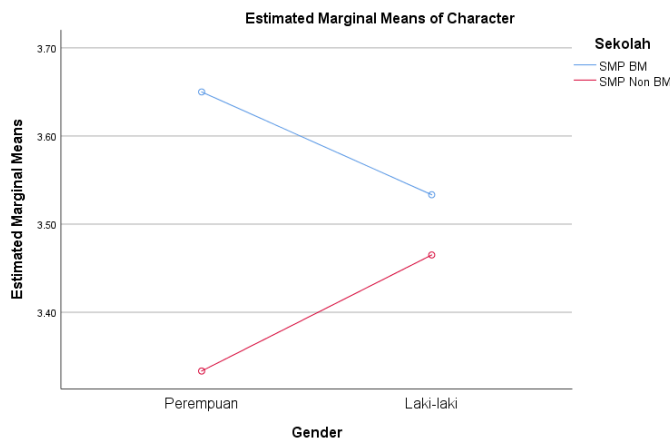


Figure 2: Comparison of Average Scores for the Character Aspect Chart

The data on character aspects (contributions) for female students at Bintang Madani Junior High School showed higher scores, while male students at non-Bintang Madani junior high schools scored higher than female students.

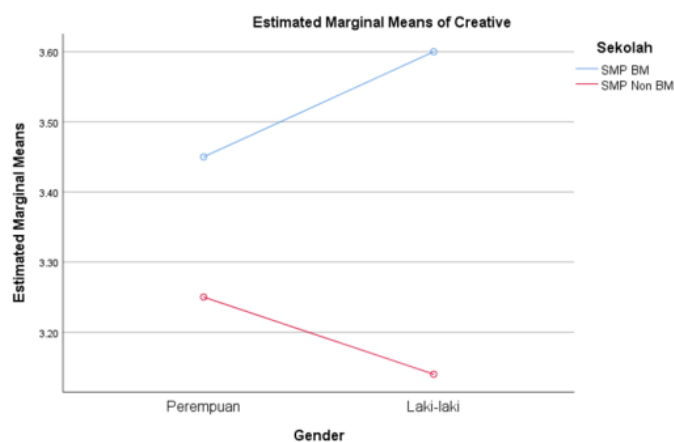


Figure 3: Comparison of Average Scores for the Creativity Aspect Chart

The highest score in the creativity category was achieved by male students from Bintang Madani Junior High School. Female students from junior high schools other than Bintang Madani scored higher than male students.

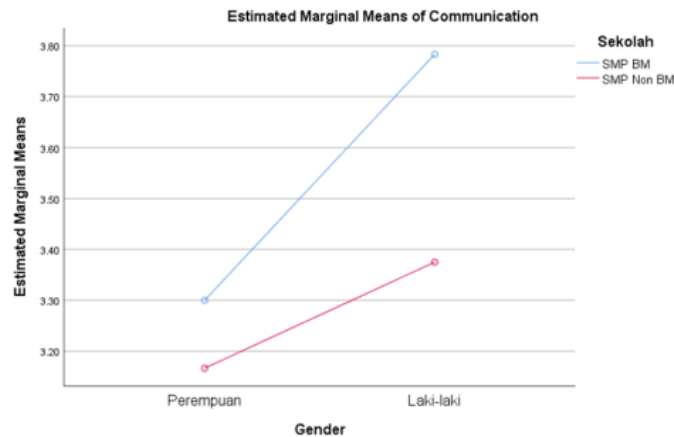


Figure 3: Comparison of Average Scores for the Communication Aspect Chart

An interesting finding relates to the aspect of communication. Male students consistently scored higher on average, both at SMP BM and at other junior high schools.

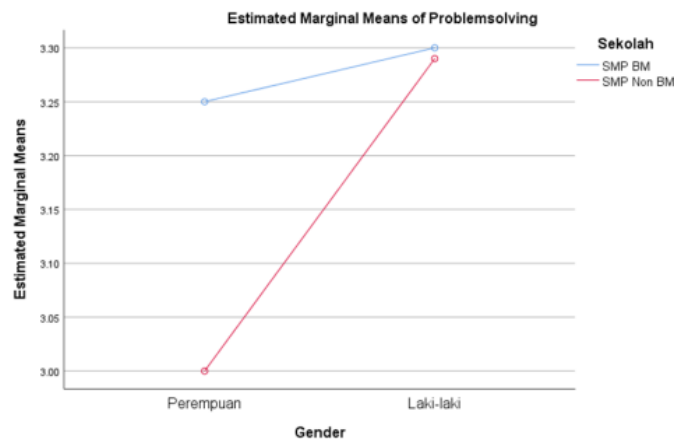


Figure 4: Comparison of Average Scores for the Problem Solving Aspect Chart

Similar to the communication aspect, in the problem-solving aspect, male students' average scores were higher than those of female students.

Table 2: Correlations Among Various Aspects of 21st-Century Skills

		Correlations				
		Collaboration	Character	Creative	Communication	Problemsolving
Collaboration	Pearson Correlation	1	.452*	.583**	.124	.471*
	Sig. (2-tailed)		.039	.006	.593	.031
	N	21	21	21	21	21
Character	Pearson Correlation	.452*	1	.435*	-.267	.208
	Sig. (2-tailed)	.039		.049	.242	.366
	N	21	21	21	21	21
Creative	Pearson Correlation	.583**	.435*	1	.273	.406
	Sig. (2-tailed)	.006	.049		.231	.068
	N	21	21	21	21	21
Communication	Pearson Correlation	.124	-.267	.273	1	.129
	Sig. (2-tailed)	.593	.242	.231		.576
	N	21	21	21	21	21
Problemsolving	Pearson Correlation	.471*	.208	.406	.129	1
	Sig. (2-tailed)	.031	.366	.068	.576	
	N	21	21	21	21	21

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the analysis of data from student assessment forms regarding their groupmates during the process of creating hydroelectric and wind power plant projects, the correlation table shown above was obtained. The strongest correlations were found between collaboration and problem-solving (significance <0.05), collaboration and creativity (significance <0.01), and collaboration and character (contribution) (significance <0.05).

Table 3: Comparison of Average 21st-Century Skills Scores from Two Projects

Students	Average Score "Powerplant Project"	Average Score "Global Warming"	Comparison
A	3.8	3.8	Equal
B	3.25	3.06	Down
C	3.8	3.71	Down
D	3.00	3.00	Equal
E	3.3	3.40	Up
F	3.05	3.91	Up
G	3.15	3.75	Up
H	3.64	3.27	Down
I	3.15	3.15	Equal
J	3.3	3.23	Down
K	3.6	3.35	Down
L	3.5	3.60	Up
M	3.25	3.27	Up
N	3.55	3.48	Down
O	3.55	2.90	Down

P	3.25	3.60	Up
Q	3.64	3.17	Down
R	3.65	3.25	Down
S	3.16	3.60	Up
T	3.2	3.46	Up
U	3.08	3.02	Down

Table 3 shows that 11 students consistently maintained and improved their scores. However, 10 students experienced a decline in their average scores. The evaluation process for the second project, which was conducted on an individual basis, required students to demonstrate their best performance. In contrast to the first project (the power plant), students presented their findings in groups. Assessment for the first project was also conducted over a three-week period.

The average scores for each aspect examined revealed differing patterns in the areas of collaboration, character, and creativity. Female students from Bintang Madani Junior High School had higher scores in collaboration and character (contribution) than male students. Female students from junior high schools other than Bintang Madani had higher scores than male students in the area of creativity. In the areas of communication and problem-solving, male students scored higher than female students.

Grouping students by gender during project work revealed that evaluations among students of the same gender tended to differ. Male students rated their groupmates' performance in communication and problem-solving as "easier" compared to female students.

Collaborative problem-solving ability is the process of gathering information and applying students' knowledge to solve problems presented during the learning process [3]. As shown in Table 2, the strongest correlation is found between the collaboration and problem-solving aspects. Additionally, the collaboration aspect also has a strong correlation with character and creativity. Collaboration is a key factor in developing 21st-century skills in students.

Conclusion

In the power plant project using a STEM approach, collaboration was the aspect most strongly correlated with the other three aspects: character, creativity, and problem-solving. An analysis of 21st-century skills in the global warming presentation showed that 11 students had an increase in their average scores, while 10 students experienced a decrease. Differences in the scoring process by classmates likely influenced the increases and decreases in students' 21st-century skills scores.

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AI Declaration

The author only used a deepl.com translator to translate from Indonesian to English

Declaration statement

This manuscript has not been previously published and is not under consideration for publication elsewhere. The authors declare no conflict of interest. The primary data used in the study are processed by author with SPSS.

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