

Elementary students' attitudes towards STEM and 21st-century skills

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ABSTRACT

Science, Technology/Engineering and Math (STEM) and 21st-century learning are very important to be applied to all students starting from their early age, including at the elementary school level. This study aimed to describe students' attitudes towards STEM and 21st-century skills according to gender and education level. This research was descriptive quantitative by explaining and comparing the results of the questionnaires given to students. Student attitudes were described based on domain of STEM, 21st-century skills, gender, and student grade level. The respondent of this study was 130 elementary students who were obtained randomly from one of the elementary schools in Yogyakarta, Indonesia. The results showed that based on the science domain, the mean score of the students was 3.23 (moderate) while mathematics domain obtained was 3.21 (moderate); technology/engineering domain obtained was 3.68 (moderate) and 21st-century skill domain obtained was 3.65 (moderate). According to gender, there was a significant difference between the attitudes of male and female students towards STEM and 21st-century skills. However, there was no significant difference based on the grade of students. Based on these findings, it is suggested that teachers or policymakers should have comprehended the student attitudes before implemented the STEM-based learning and 21st-century skills. These findings can be used to create STEM and 21st-century learning.

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1. INTRODUCTION

There are many important things that students have to possess in this era, namely developing inquiry skills and stimulating positive attitudes towards Science, Technology/Engineering and Math (STEM) education [1]. Educators and the school community need to integrate STEM in learning because it can benefit the national economy [2]. STEM integration aims to combine multiple disciplines as a way to engage students in topics of interest while teaching critical thinking and core content knowledge for future success in STEM careers [3]. However, at the end of the learning phase at primary school level, many students find science boring, difficult, and irrelevant to their lives [4]. For that reason, the number of students studying and entering STEM fields is decreasing, even though there are more and more STEM jobs available [5].

The low interest of students in understanding STEM remains one of the main concerns of the stakeholders in this era [6]. In addition, students' attitudes and work interests in the STEM field continue to change throughout the years both in their primary and secondary schools [7]. Students' attitudes towards STEM subjects vary widely and generally decline during the first year of high school due to number of

changes in their attitudes [8]. In fact, there are many things needed by the students who want to work in the fields of STEM to advance global competitiveness and economic growth [9].

To motivate them to continue their studies and careers in the STEM field, developing an understanding of the interesting characteristics of STEM and describing individuals working in the STEM field can be an important steps to take [10]. STEM education contributes to transforming students into producers, not just recipients of knowledge and technology, and encourages critical, creative and problem-solving thinking [11]. Therefore STEM education has become a central topic in the field of education in relation to learning outcomes [12].

Based on the previous explanation, a study that focuses more on the development of attitudes in the context of teaching science and techniques integrated informal learning is needed [13]. A better understanding of student attitudes and the relationship between learning choices and future work choices will lead to changes in learning to support students, particularly in these difficult subjects such as STEM [14]. In addition, STEM education programs targeted at younger students (basic education) have a greater positive impact [15]. To support this education, this study will describe the attitudes of elementary students towards STEM and 21st-century skills. The results of this study are expected to support STEM and 21st-century based learning policies for elementary students. This is because measuring the impact of a STEM program on student attitudes is very important in making decisions that are relevant to the design and implementation of future programs [16].

2. RESEARCH METHOD

This study aimed to describe students' attitudes toward Science, Technology/Engineering and Math (STEM) and 21st-century skills based on gender and student grade level. There were 130 elementary school students in grades 4, 5, and 6 who were randomly selected from a public elementary school in Yogyakarta, Indonesia. There were 70 male students and 60 female students participated in this study. The items of this study were modified according to Unfried, *et al.* [17].

There are 41 items of students' attitudes towards STEM and 21st-century skills divided into 8 items for the science, 11 items for technology/technique, 9 items of mathematics, and 13 items for the 21st-century skills. All participants were asked to fill out a questionnaire that was distributed in the form. Each item consists of a scale of 1-5 which must be filled in by all participants. Table 1 shows the indicators of the test items used.

Data analysis was performed using quantitative descriptive methods. Students' attitudes towards STEM and 21st-century skills were described in several aspects including the domain of STEM and 21st-century skills, gender, and the students' grade. To determine the level of students' attitudes towards STEM, the rubric of the given questionnaire was grouped as seen in Table 2.

Table 1. Indicator of items

Domain	Indicator	Item
Math	Mathematics is an important subject for everyday life	1
	My math score was worse than others	2
	In the future, I will work in mathematics	3
	Math is the most difficult subject	4
	In the future, I need to understand the math for my job	5
	I am the type of student who is good at math	6
	In the future, I will be able to do more difficult math problems	7
	I can get good grades in math	8
	I'm good at math	9
Science	I feel comfortable when I study science	10
	In the future, I want to work in science	11
	I will often use science after graduating from elementary school	12
	In the future, knowing science will help me make money	13
	in the future, I need to understand science for my job	14
	I know I can do well in science	15
	Science will be important for me to work on later	16
	I can understand most subjects easily, but science is difficult for me	17
Engineering/Technology	I like to imagine creating new masterpieces	18
	If I learn engineering/technology, then I can find new things that people can use every day	19
	I'm good at building or fixing things	20
	Understanding the engineering/technology will help me make money	21
	I am interested in what causes a machine to start	22
	Designing works or buildings is important in my future	23
	I want to know about how electronics work	24
	I will choose a job that involves building activities or producing something	25
	I want to be creative in my job	26
	Knowing how to use math and science together will help me find useful things	27
21st-century skill	I believe I can be successful in producing new thing	28
	I can lead others to achieve goals	29
	I like to help others so that they can do their best	30
	I usually know how to do the right thing	31
	At school and at home, I can do many things well	32
	I usually act responsibly	33
	I respect all my friend even though they are different from me	34
	I try to help my friend	35
	When I make decisions, I think about what's good for the other person	36
	When things don't go the way I want, I can change my actions for the better	37
	While studying, I can set my own goals	38
	I can use my time wisely when working alone	39
	When I have a lot of homework, I can choose what to do first	40
	I can cooperate with all students, even if they are different from me	41

Table 2. Rubric of questionnaire

Range	Level
$x \leq 2.00$	Very low
$2.00 < x \leq 3.00$	Low
$3.00 < x \leq 4.00$	Moderate
$4.00 < x \leq 4.50$	High
$4.50 < x \leq 5.00$	Very high

3. RESULTS AND DISCUSSION

This section describes the results of students' attitudes toward Science, Technology/Engineering and Math (STEM) and 21st-century skills. The instrument was analysis using SPSS. The result showed that reliability scale was high, where the alpha Cronbach value was 0.92 and the validity of the item is shown in Table 3. According to Table 3, item 2, 3, and 4 were not valid ($r < r_{\text{table}} 0.172$) while other items were valid.

Table 3. Validity test

Item	Validity score	Description	Item	Validity score	Description	Item	Validity score	Description
1	0.336	Valid	15	0.659	Valid	29	0.574	Valid
2	0.007	Not Valid	16	0.604	Valid	30	0.638	Valid
3	0.164	Not Valid	17	0.212	Valid	31	0.679	Valid
4	0.137	Not Valid	18	0.411	Valid	32	0.635	Valid
5	0.392	Valid	19	0.599	Valid	33	0.731	Valid
6	0.362	Valid	20	0.357	Valid	34	0.595	Valid
7	0.331	Valid	21	0.655	Valid	35	0.482	Valid
8	0.538	Valid	22	0.433	Valid	36	0.611	Valid
9	0.398	Valid	23	0.488	Valid	37	0.580	Valid
10	0.552	Valid	24	0.504	Valid	38	0.574	Valid
11	0.491	Valid	25	0.493	Valid	39	0.601	Valid
12	0.329	Valid	26	0.675	Valid	40	0.623	Valid
13	0.554	Valid	27	0.620	Valid	41	0.533	Valid
14	0.601	Valid	28	0.684	Valid			

3.1. Students' attitude toward STEM and 21st-century skill based on the subject

In this section, the students' attitudes towards STEM and 21st-century skill were described according to the subject or aspect. Table 4 shows the analysis of students' answers to the given questionnaire. On the mathematics domain, the highest average indicator for elementary school students in grades 4, 5, and 6 is an important subject for everyday life (item 1) with a score of 4.23 (high); while the lowest indicator is the most difficult subject (item 4) with a score of 2.52 (low). According to the science domain, the highest average is item 12, "After graduating from elementary school, I will often use science" with a score of 3.47 (moderate) while the lowest indicator is I can understand most subjects easily, but science is hard for me (item 17) with a score of 2.61 (low). On to the technology/engineering domain, the highest mean is "I like to imagine creating new masterpieces" (item 18) with a score of 3.95 (high) while the lowest indicator is "I'm good at building or fixing things" (item 20) with a score of 3.38 (high). According to the 21st-century skills, the highest average indicator of elementary school students is "I like to help others so that they can do their best" (item 30) with 4.09 (high) while the lowest indicator is "I can make my own goals" (item 38) with a score of 3.19 (moderate). We also examined whether the dimension of STEM has an effect toward 21st-century skill using Linear Regression test. The result is shown in Table 5.

Table 4. Students' attitudes toward STEM and 21st skill

Math			Science			Technology/Engineering			21st-century skill		
Item	Mean	Description									
1	4.23	High	10	3.23	Moderate	18	3.95	Moderate	29	3.47	Moderate
2	2.67	Low	11	2.95	Low	19	3.61	Moderate	30	4.09	High
3	2.85	Low	12	3.47	Moderate	20	3.38	Moderate	31	3.57	Moderate
4	2.52	Low	13	3.42	Moderate	21	3.76	Moderate	32	3.85	Moderate
5	3.81	Moderate	14	3.47	Moderate	22	3.47	Moderate	33	3.47	Moderate
6	2.90	Low	15	3.38	Moderate	23	3.61	Moderate	34	3.71	Moderate
7	3.23	Moderate	16	3.33	Moderate	24	3.85	Moderate	35	3.62	Moderate
8	3.47	Moderate	17	2.61	Low	25	3.61	Moderate	36	3.62	Moderate
9	3.28	Moderate				26	3.76	Moderate	37	3.90	Moderate
						27	3.76	Moderate	38	3.19	Moderate
						28	3.76	Moderate	39	3.52	Moderate
									40	3.47	Moderate
									41	4.00	Moderate
Overall: 3.25 (Moderate) SD: 0.56			Overall: 3.23 (Moderate) SD: 0.30			Overall: 3.68 (Moderate) SD: 0.17			Overall: 3.65 (moderate) SD: 0.25		

Table 5. Linear regression test

Model	Unstandardized coefficients		Standardized coefficients	t	Sig
	B	Std. Error	Beta		
(Constant)	4.512	1.164		3.875	.018
Science	-.237	.168	-.346	-1.413	.230
Math	-.308	.090	-.874	-3.409	.027
Technology/Engineering	.251	.282	.229	.892	.423

Note: Dependent variable: 21st-century skill

3.2. Students' attitude toward 21st-century skill and STEM based on gender

In this section, the students' attitudes towards STEM and 21st-century skill were described according to the gender. There are 70 male students and 60 female students in total. The results can be seen

Elementary students' attitudes towards STEM and 21st-century skills (Riki Perdana)

in Table 6. On the mathematics domain, the highest mean indicator for male students is "Mathematics is an important subject for everyday life (item 1)" with a score of 4.11 (high) while the lowest indicator is "My math score was the worse than other (item 2)" with a score of 2.58 (low). Meanwhile, the highest mean indicator for female students is "In the future, I need to understand the math for my job (item 5)" with a score of 4.0 (moderate) while the lowest indicator is "My math score was the worse than others (item 2)" with a score of 2.78 (low).

On the science domain, the highest mean indicator of male students is the "I feel comfortable when I study science (item 10)" with a score of 3.94 (moderate) while the lowest is "I can understand most subjects easily, but science is difficult for me (item 17)" with a score of 2.82 (low). Meanwhile, the highest mean for female students is "I know I can do well in science (item 15)" with 3.71 (moderate) while the lowest indicator for female students is "I can understand most subjects easily, but science is difficult (item 17)" with a score 2.60 (low).

On the technological/engineering domain, the highest mean of male students is "I believe I can be successful in producing new thing (item 28)" with a score of 4.15 (high) while the lowest is "I'm good at building or fixing things (item 20)" and "I will choose a job that involves building activities or producing something (item 25)" with a score of 3.55 (moderate). Meanwhile, the highest mean for females is "Knowing how to use math and science together will help me find useful things (item 27)" with a score of 4.11 (high) while the lowest is "I'm good at building or fixing things (item 20)" with a score of 3.05 (moderate).

On the 21st-century skills domain, the highest and lowest mean indicator of male and female students are the same. The highest mean is "I respect all children my age even though they are different from me (item 34)" with a score of 4.15 (high) for males and 4.08 (high) for females. The lowest mean is "I can use my time wisely when working alone (item 39)" with a score of 3.62 (moderate) for males and 3.56 (moderate) for females. To further obtaining better understanding, the Manova test was conducted to prove whether there were significant differences in attitudes towards STEM and 21st-century skills based on gender. There are significant differences in STEM attitudes and 21st-century skills based on gender where the sig value is ($0.016 < 0.05$). Table 7 shows the dimensions that show significant differences in students' attitude toward STEM and 21st-century skills based on gender.

Table 6. Students' attitude toward STEM and 21st-century skill based on gender

Item	Male		Female		Item	Male		Female	
	Mean	Description	Mean	Description		Mean	Description	Mean	Description
1	4.11	High	3.85	Moderate	22	3.88	Moderate	3.23	Moderate
2	2.58	Low	2.78	Low	23	3.65	Moderate	3.38	Moderate
3	2.65	Low	2.98	Low	24	4.04	High	3.65	Moderate
4	3.04	Moderate	2.83	Low	25	3.55	Moderate	3.25	Moderate
5	3.94	Moderate	4.00	Moderate	26	4.07	High	4.01	High
6	2.88	Low	3.01	Moderate	27	3.92	Moderate	4.11	High
7	3.31	Moderate	3.48	Moderate	28	4.15	High	4.08	High
8	3.67	Moderate	3.70	Moderate	29	3.64	Moderate	3.58	Moderate
9	3.14	Moderate	3.10	Moderate	30	4.24	High	4.00	Moderate
10	3.94	Moderate	3.67	Moderate	31	3.94	Moderate	3.73	Moderate
11	3.20	Moderate	2.92	Low	32	4.00	Moderate	3.80	Moderate
12	3.62	Moderate	3.45	Moderate	33	3.75	Moderate	3.56	Moderate
13	3.62	Moderate	3.48	Moderate	34	4.15	High	4.08	High
14	3.54	Moderate	3.60	Moderate	35	3.80	Moderate	3.75	Moderate
15	3.54	Moderate	3.71	Moderate	36	3.91	Moderate	3.83	Moderate
16	3.57	Moderate	3.61	Moderate	37	3.97	Moderate	3.88	Moderate
17	2.82	Low	2.60	Low	38	3.77	Moderate	3.58	Moderate
18	4.10	High	3.60	Moderate	39	3.62	Moderate	3.56	Moderate
19	3.92	Moderate	3.60	Moderate	40	3.87	Moderate	3.92	Moderate
20	3.55	Moderate	3.05	Moderate	41	4.08	High	4.03	High
21	3.81	Moderate	3.68	Moderate					
Overall male=3.68 (moderate); SD=0.42					Overall female=3.56 (moderate); SD=0.39				

Table 7. Test between Manova

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Gender	Science	.031	1	.031	.147	.702
	Math	.210	1	.210	.489	.486
	Technology engineering	2.723	1	2.723	8.255	.005
	Century skill	.415	1	.415	.962	.329

3.3. Students' attitude toward 21st-century skill and STEM based on their grade

In this section, the students' attitudes towards STEM and 21st-century skill were described according to their grade. There were 40 students at grade 4, 34 students at grade 5, and 54 students at grade 6 joining this study. The results can be seen in the Table 8.

In grade 4, the highest mean of attitude toward math is "When I grow up, I need to understand the math for my job (item 5)" with a score of 4.0 (moderate) while the lowest mean is "My math score was worse than others (item 2)" with a score of 2.55 (low). The highest mean of attitude toward science is the "I feel comfortable when I study science (Item 10)" with a score of 3.62 (moderate) while the lowest is "I can understand most subjects easily, but science is difficult for me (item 10)" with a score of 2.53 (low). The highest mean of attitude toward technological/technical is "I believe I can be successful in producing new things (item 28)" with a score of 4.06 (high) while the lowest mean is "I am good at building or repairing something (item 20)" with a score 3.16 (moderate). The highest mean of 21st-century skill is "I like to help others so they can do their best (item 30)" with a score of 4.06 (high) while the lowest is "I can lead others to reach goals (item 29)" with a score of 3.53 (moderate).

In grade 5, the highest mean for math is "In the future, I need to understand the math for my job with (item 5) with a score of 4.05 (high) while the lowest is math the hardest subject for me (item 4)" with a score of 2.79 (low). The highest mean for science is "In the future, knowing science will help me make money (item 13) and I need to understand science for my job (item 14) with a score of 3.76 (moderate) while the lowest is "I can understand most subjects easily, but science is difficult for me (item 17)" with a score of 3.0 (low). The highest mean for the technological/technical is "I like to imagine creating new thing (item 18)" with a score of 4.02 (high) while the lowest is "I am good at building or repairing something (Item 20)" with a score of 3.47 (moderate). The highest mean 21st-century skill is "I like to help others so that they can do their best (item 30)" with a score of 4.02 (high) while the lowest is "I can use my time wisely when working alone (item 39) and I usually act responsibly (item 33)" with a score of 3.61 (moderate).

In grade 6, the highest mean for math is "Mathematics is an important subject for everyday life (item 1)" with a score of 4.0 (moderate) while the lowest is "My math score was the worse than the other subjects (item 4)" with a score of 2.70 (low). The highest mean for science is "I feel comfortable when I study Science with (item 10)" with a score of 4.05 (high) meanwhile the lowest is "I can understand most subjects easily, but science is difficult for me (item 17)" with a score of 2.70 (low). The highest mean for technological/technical is "I want to be creative in my future work (item 26)" with a score of 4.16 (high) while the lowest is "I will choose a job that involves building activities or producing works of something (item 25)" with a score of 3.28 (moderate). The highest mean for 21st-century skill is "I like to help others so that they can do their best (item 30)" with a score of 4.24 (high) while the lowest is "I respect all children at my age even differ from me (item 34)" with a score of 3.24 (moderate). Table 9 shows the dimensions that show significant differences in students' attitude toward STEM and 21st-century skills based on grade.

Table 8. Students' attitude toward STEM and 21st-century skill based on grade

Item	Grade			Item	Grade		
	4	5	6		4	5	6
1	3.95	4	4	22	3.55	3.73	3.51
2	2.55	2.8	2.7	23	3.53	3.73	3.4
3	2.86	2.97	2.66	24	3.79	3.79	3.4
4	2.95	2.79	3.03	25	3.34	3.7	3.28
5	4.00	4.05	3.88	26	3.95	3.97	4.16
6	2.90	3.17	3.00	27	4	3.97	4.05
7	3.32	3.44	3.41	28	4.06	4.00	4.24
8	3.81	3.50	3.70	29	3.53	3.82	3.54
9	3.11	3.26	3.03	30	4.06	4.02	4.24
10	3.62	3.67	4.05	31	3.86	3.76	3.88
11	2.90	3.17	3.13	32	3.90	3.85	3.94
12	3.53	3.67	3.47	33	3.58	3.61	3.77
13	3.37	3.76	3.58	34	4.02	3.82	3.40
14	3.37	3.76	3.60	35	3.93	3.79	3.64
15	3.55	3.50	3.75	36	3.81	3.85	3.94
16	3.53	3.55	3.66	37	3.88	3.91	3.98
17	2.53	3.00	2.70	38	3.55	3.79	3.71
18	3.60	4.02	3.98	39	3.62	3.61	3.56
19	3.60	3.85	3.86	40	3.67	3.82	4.11
20	3.16	3.47	3.35	41	4.04	3.97	4.13
21	3.72	3.82	3.73		3.57	3.65	3.61
	Overall				(high)	(high)	(high)

Table 9. Manova test based on grade

	Effect	Value	F	Sig.
Grade	Pillai's Trace	.058	.919	.501
	Wilks' Lambda	.943	.913 ^a	.506
	Hotelling's Trace	.060	.908	.511
	Roy's Largest Root	.041	1.256 ^c	.291

Table 7 infers that the dimensions showing significant differences are technology and engineering. Although the value of the effect size found is quite small, Cai, Fan, and Du [18] also concluded that men have a better attitude towards the use of technology than women. This finding is similar to Han [19] where male students with positive attitudes towards technology-based learning are more likely to choose STEM majors, while female students are indirectly influenced by belief in the benefits of STEM. Male students who attended technical education programs had higher attitudes towards engineering than female students who attended the same program [20].

Based on the Table 8 results of the above data analysis, it appears that the average student attitudes towards STEM and 21st-century skills are at a high level for each class. These results indicate that there is no significant difference in student attitudes towards STEM and 21st-century skills by class. The MANOVA test was also used to prove this result. As shown in the table, the sig value is >0.05 so that we can conclude that there is no significant difference by class on students' attitudes towards STEM and 21st-century skills. This finding is similar to Karakaya and Avgın [21] who stated that class differences do not affect students' attitudes towards STEM.

Overall students' attitude toward STEM and 21st-century skill were at moderate level. Beside, attitudes about STEM education have a significant relationship with their perceived proficiency in 21st-century skills [22]. Therefore, to become science and technology innovators and be competitive in the 21st-century, schools need to produce STEM literate and competent in 21st-century skills students [23]. One of the ways to increase students' attitudes and interest in STEM is by implementing STEM education [24]. The application of STEM-based learning in certain subjects can improve student attitudes while helping students develop positive perceptions of STEM [25]. The results of this study are similar to Popa and Ciascai [26] where students are indeed interested in the STEM field. This result is different from Suprpto [27] which shows that the mathematical domain is higher than science, but when viewed from the average score in this study, it is relatively the same. On other hands, math is the lowest dimension. Students appear to have difficulty in mathematics [28], so that their attitudes are lower. This may occur because the problems in mathematics are related to contextual matters [29] or constructing concepts through real contexts [30] and requires critical thinking [31].

Based on the significance value, Table 5 shows that there is no significant effect of students' attitudes on the science and technology dimension toward their 21st-century skills. But according to this result, math gives significant impact on 21st-century skill. This finding is similar to Nakakoji and Wilson [32] who state that mathematics is very important and supports the development of 21st-century skills. In addition, the characteristics of mathematics are to develop and apply a mathematical thinking style to solve daily life problems, so that it is very suitable for 21st-century skills [33]. Mathematical attitudes are aimed at stimulating creative activity and innovation in 21st education [34], so that they are in line with the characteristics of 21st-century skills. In addition, technological attitudes are also very important for 21st-century learning because it is found that students' cognitive concepts in technology or digital literacy are still low [35], [36].

According to gender aspect, this finding is similar to previous study [37] where male students are more interested in future careers in STEM compared to female students. Rehman and Butt [38] also stated that female lose interest and intention to major in STEM. It seems that female are not interested or prefer to avoid STEM which may be due to gender bias so that they are underrepresented in STEM [39]. This attitude of female students has been proven by Sassler, *et al.* [40] who stated that women have a lower chance of entering STEM jobs than men until controls for college majors are added. In math, previous study [41] also found that more girls in school felt tense doing math problems compared to boys of the same age. It has been found that boys are relatively better at science and math while girls are relatively better at reading than other academic fields, which is why there is a potential for gender differences in STEM education [42].

4. CONCLUSION

Overall student attitudes towards Science, Technology/Engineering and Math (STEM) and 21st-century skills are at a moderate level. Almost all STEM domains are not positively related to 21st-century skills. Only mathematics domains are positively related to 21st-century skills. There is a significant

difference in students' attitudes towards STEM and 21st-century skills by gender. The STEM domains that have the most influence based on gender are technology and engineering, where female student lost their interest in engineering domain. In addition, there are no significant differences in students' attitudes towards STEM and 21st-century skills based on grade (4th, 5th, and 6th).

The educational institution should focus on female students and the grade or class of students may be not considered. The limitation of this study is that it only measures the attitudes of elementary school students in the upper class, not measuring the lower class. In addition, there is no explaining what causes student attitudes that are not high towards STEM and 21st-century skills. Further research can be carried out by investigating the causes of students' low attitudes towards STEM and 21st-century skills not only at the primary school level, but also at the middle to high levels.

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