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Abstract

Students are expected to have 21st century skills and be STEM literate for successful future careers. Teachers who will include teaching practices to develop these skills should have these competencies. Therefore, it is important how teachers perceive 21st century competencies and STEM education or what kind of tendencies they have in this context. This study aims to examine science teachers' self-efficacy perceptions towards 21st century skills and their STEM attitudes and to reveal the relationship between them. Fifty teachers working in a city in Turkey participated in the study in which the concurrent mixed methods research design was used. Scales of self-efficacy perceptions towards 21st century skills and STEM attitudes were used as data collection tools. Independent sample t-test, Mann Whitney U test (MWU), Kruskal Wallis-H test (KWH) and Spearman Correlation analysis were used in the analysis of the data. In the study, a significant and positive relationship was determined between teachers' self-efficacy perceptions and their STEM attitudes. It was determined that teachers with self-efficacy perception had positive STEM attitudes. Qualitative data consisting of teachers' opinions supports these findings. It was observed that while teachers' gender and professional seniority did not make a difference in self-efficacy perceptions, STEM attitudes differed in favour of women according to gender, and there was no difference according to professional seniority.

Introduction

The aim of education systems in the 21st century technology age is to raise individuals who are developing and adapting to the changing world with science and technology. Information that was not easily accessible to everyone in the past has now been presented in digital environments thanks to information technologies, eliminating the time and space limitations in accessing information. Therefore, presenting direct information has become a mission to provide students with basic skills and 21st century skills that have come out of the orientation of today's education systems. Entrepreneurs and productive individuals who are open to new ideas and who can solve problems and who think creatively and critically are sought to be successful both in business life and social life (Sarı, Çelik, Pektaş & Yalçın, 2022). These cognitive, personal and interpersonal skills and abilities required to function effectively in the 21st century business world are often referred to as 21st century skills (Anagün, Atalay, Kılıç & Yaşar, 2016). It is noticed that there is no universal classification for 21st century skills in the literature, and they are classified differently in different sources (Voogt & Roblin, 2012). According to Partnership for 21st Century Skills (P21) (2015), 21st century skills are grouped under three titles: "learning and innovative skills", "life and career skills" and "information media and technology skills". *Learning and innovative skills* include creativity and innovation, critical thinking and problem-solving, communication and collaboration skills that prepare students for an increasingly complex life. The skills referred to as *life and career skills* are flexibility and practicability, initiative and self-direction, social and intercultural skills, productivity and accountability, leadership and responsibility. Skills such as information and communication literacy and media literacy are classified as *information media and technology skills*. Osman, Soh and Arsad (2010) used five titles for 21st century skills: "digital age literacy", "creative thinking", "effective communication", "high productivity" and "moral values". It is understood that cooperation, problem-solving, creative thinking and critical thinking are included in almost all of these classifications in the literature.

21st century skills are important for individuals to lead a more qualified and productive life. Therefore, countries tend to include these skills in their education programs to raise qualified individuals with these skills (Atabey & Topcu, 2021; Haug & Mork, 2021). These skills are included in the curriculum in Turkey as in many countries. Skills such as critical thinking, creative thinking, communication, research, problem-solving, decision making, using information technologies and entrepreneurship are included as common skills in primary and secondary school education programs (Kalemkuş, 2021). It has been tried to be reflected within the achievements, not under a separate heading by integrating 21st century skills into the curriculum renewed in 2017. In addition, literacy was defined within the scope of 21st century skills, and personal and interpersonal skills were included (MEB, 2017). On the other hand, the most important stakeholder in the success of the curricula prepared in the light of 21st century skills are the teachers in the role of practitioners. Teachers should also have relevant competencies in line with these skills that are aimed to be acquired by students. If the teacher is insufficient to use the necessary skills in the learning environment, this may negatively affect the motivation of the student (Gürültü, Aslan & Alcı, 2019). A teacher with sufficient skills in terms of using 21st century skills can affect the students positively and be effective in the success of the curriculum and in acquiring the necessary skills. In this context, teachers' self-efficacy can also determine teaching practices and effectiveness (Woolfolk, Winne, Perry & Shapka, 2009) because teachers' self-efficacy refers to "teachers' beliefs that they have the ability to perform certain teaching behaviours that affect students' educational outcomes, such as achievement, interest and motivation." (Ainley & Carstens, 2018). Teachers with high self-efficacy can improve the quality of teaching as a reflection of their greater belief in their students and their abilities (Geng, Jong & Chai, 2019; Zakariya, 2020). Teachers' self-efficacy for 21st century skills should be considered directly in terms of the quality of their practice and can be a strong indicator of their confidence and ability to teach 21st century skills (Woolfolk, Winne, Perry & Shapka, 2009). Therefore, teachers' self-efficacy for 21st century skills can contribute to the development of students' 21st century skills. For this reason, one of the issues addressed in this study is science teachers' self-efficacy perceptions towards 21st century skills.

The efforts of countries to raise individuals with 21st century skills keep STEM (science, technology, engineering, mathematics) education on the agenda (Sarı, Alıcı &Şen, 2018). STEM education is an interdisciplinary approach that contributes to multidimensional thinking and the development of life skills (Bybee, 2010). This approach has a great contribution to raising technology-literate individuals with problem-solving skills, creative, innovative and logical thinking (Morrison, 2006). In this context, STEM education plays an important role in shaping culture and economic development (Cooper & Heaverlo, 2013). Therefore, STEM practices are observed in countries with developed education systems and strong economies such as America, Germany, England, China, Japan and Finland (Sarı, Alıcı &Şen, 2018; Mystakidis, Christopoulos & Pellas, 2022). In recent years, many practices and studies have been carried out in the field of STEM education in Turkey (Sarı, Duygu, Şen, & Kirindi, 2020; Sarı, Pektaş, Şen & Çelik, 2022). These studies were also reflected in the education programs, and STEM education took place in the 2018 Science curriculum in terms of knowledge, skills and affective dimensions (MEB, 2018).

Jobs in the STEM field have a significant impact on the development of a nation's technological innovation, economic growth, global competitiveness and living standard (Langdon, McKittrick, Beede, Khan & Doms, 2011). On the other hand, the reports published in Turkey in recent years state the inadequacy of the STEM workforce in the country and express the need for improvement (Yazıcı, Hacıoğlu & Sarı, 2022). STEM education must be implemented and disseminated efficiently to train a STEM workforce with 21st century skills. Teachers' STEM attitudes are important in realizing this situation (Hackman, Zhang & Jingwen He, 2021; Sahin-Topalcengiz & Yildirim, 2019). According to Eccles and Wigfield (2002), attitude can be considered as a combination of self-efficacy and expectation-value beliefs. Teachers' attitudes towards STEM education refer to a teacher's views, mood or feelings towards STEM in a constructivist classroom teaching and learning practice (Thibaut, Knipprath, Dehaene & Depaepe, 2018). While teachers with positive attitudes towards STEM enjoy teaching in an integrated way, teachers with negative perceptions tend to avoid interdisciplinary teaching (Thibaut et al., 2018). Therefore, the success of teachers' STEM education initiatives depends on teacher attitudes. The teacher's attitude determines the level of their commitment to incorporate STEM education principles into their daily classroom practice (Al Salami, Makela & De Miranda, 2017). To increase students' perceptions and interest in STEM, teachers need to have a positive attitude towards STEM education beyond their discipline and be willing to change existing teaching strategies. In this context, it would be useful to examine the attitudes of science teachers, who are the practitioners of STEM education, towards STEM. On the other hand, teachers' self-efficacy, which is an indicator of their self-confidence, can affect the attitude. Especially considering that the goal of STEM education is to develop 21st century skills in students and it includes some special applications for the development of these skills, teachers' self-efficacy perceptions towards 21st century skills may affect STEM attitudes. Therefore, another focus of this study was the relationship between teachers' self-efficacy perceptions and STEM attitudes. In this study, it is aimed to examine science teachers' perceptions of 21st century skills, self-efficacy and attitudes towards STEM education in terms of differentiation status according to gender and professional seniority variables and the relationship between them. In addition, it was aimed to support quantitative data by evaluating teachers' 21st century skills and views on STEM education. More specifically, the following questions will be answered:

1. What is the level of science teachers' self-efficacy perceptions towards 21st century skills, and STEM attitudes?
2. Is there a significant difference in science teachers' self-efficacy perceptions towards 21st century skills, and STEM attitudes according to gender and professional seniority?
3. Is there a relationship between science teachers' self-efficacy perceptions towards 21st century skills, and STEM attitudes?
4. What are science teachers' views on 21st century skills and STEM education?

Literature Review

21st century skills range from individual skills to social skills including workforce, life and career, media and information, technology, etc. (Kelley, Knowles, Han & Sung, 2019). Due to the increasing importance of these skills in the business world, there is a high tendency for research in this direction in recent years (Haug & Mork, 2021; Zhong, Guo, Su & Chu, 2022). According to Abualrob (2019), the role of teachers is very important in acquiring 21st century skills for students. Therefore, as teaching practitioners, teachers should have these skills and use them in their lessons. There is strong evidence in the literature that the most important factor affecting teachers' teaching practices is teachers' self-efficacy beliefs (Ainley & Carstens, 2018; Zakariya, 2020). Woolfolk et al. (2009) stated that teachers' self-efficacy will directly affect the quality of their practices as a proof of their self-confidence and skills. Wilborn (2013) revealed that if teachers' self-efficacy perceptions of 21st century skills are positive, this is reflected in their practices. Kara et al. (2022) found that teachers' perceptions of 21st century skills self-efficacy are significantly affected by their professional self-efficacy and have a significant impact on students' perceptions of learning experience. Çimen (2022) determined that there is a moderate positive relationship between teachers' perceptions of self-efficacy and efficacy towards teaching skills.

In recent years, many studies have focused on developing 21st century skills through STEM education (Han, Kelley & Knowles, 2021; Jang, 2016; Li et al.,2019). Research indicates that STEM education is an excellent tool in the application of 21st century skills and thus gaining individuals (Cooper & Heaverlo, 2013, Sarı, Duygu, Şen, & Kirindi, 2020). In this sense, teachers' attitudes towards STEM education are effective in the efficient implementation of STEM education (Hackman, Zhang & Jingwen He, 2021). Therefore, teachers' STEM attitudes should be investigated and developed positively. Thibaut et al. (2018) stated that teachers' attitudes are related to classroom practices and that teachers with negative attitudes towards STEM tend to avoid teaching STEM. In another study, they found that secondary school teachers' STEM teaching attitudes were positively related to three aspects: professional development, personal interest in science and social context (Thibaut et al., 2019). According to the literature, professional and administrative support, peer collaboration, and STEM-oriented training for teachers positively affect teachers' attitudes towards STEM education (Hackman, Zhang & Jingwen He, 2021).

When the studies discussed above are evaluated, it is observed that teachers' 21st century skill levels and their STEM attitudes are mostly examined separately. In only one study, it is observed that teacher candidates' attitudes towards STEM and self-efficacy towards 21st century skills were evaluated together, and the relationship between them was examined (Kan & Murat, 2018). At this point, examining the STEM attitudes and self-efficacy perceptions of science teachers (the practitioners of STEM education) towards 21st century skills and revealing the relationship between the two will contribute significantly to the literature.

Method

Research Model

Concurrent mixed methods research design, which is one of the mixed methods in which quantitative and qualitative data are used together, was used in the study (Creswell & Plano Clark, 2018). Although this study primarily uses a relational survey model to explore the link between science teachers' perceptions of self-efficacy and their attitudes towards STEM, it is crucial to acknowledge the limitations of relying solely on quantitative measures. Therefore, by including qualitative data, it was aimed to understand the complex relationship between these variables more deeply and to make a comprehensive analysis of the phenomenon under investigation. In this context, quantitative and qualitative data were collected and analysed more or less simultaneously. The data analysis was made with each other and combined in the data interpretation and discussion sections.

Study Group

The study was carried out with science teachers working in a city in the Central Anatolian region in 2021. Easily accessible sampling was preferred in determining the study group. In this context, 50 (25 female, 25 male) teachers who are easily accessible and willing to participate in the study were included in the study. Although convenience sampling has its limitations, it can still offer valuable insights and meaningful results. While it may not ensure a fully representative sample, convenience sampling is not primarily focused on generalizing findings to a larger population. Instead, its main purpose is to explore the relationship between variables within the selected group. Table 1 shows the distribution of teachers participating in the study by seniority.

Table 1. Distribution of gender and professional seniority of science teachers

Tenure	f	%
1-5 years	10	20
6-10 years	13	26
11-15 years	14	28
16 years and above	13	26
Gender	f	%
Female	25	50
Male	25	50

Data Collection Tools

STEM Attitude Scale: In the study, the "STEM Attitude Scale" developed by İnam (2020) was used to determine teachers' STEM attitudes. The Likert-type scale, consisting of 24 items, has two sub-dimensions: "STEM activities" and "lesson planning". During the development of the scale, the Cronbach Alpha coefficient for the whole scale regarding reliability analysis was calculated as .916 for the "STEM activities" sub-dimension, .953 and for the "lesson planning" sub-dimension as .832 (İnam, 2020). Table 2 shows the Cronbach Alpha values for this study.

Table 2. Cronbach alpha values of the STEM attitude scale

Dimensions	N	Cronbach's Alpha
STEM Activities	19	,972
Lesson Planning	5	,916
STEM Attitude Scale (in general)	24	,944

Scale for self-efficacy perception towards 21st century skills: The Scale for self-efficacy perception towards 21st century skills developed by Anagün, Atalay, Kılıç and Yaşar (2016) was used in the study. The scale consists of 3 sub-dimensions: "learning and renewal skills", "life and career skills" and "information media and technology skills", and a total of 42 items. The five-point Likert scale was chosen as Never (1), Rarely (2), Sometimes (3), Often (4) and Always (5). Cronbach Alpha value for the overall reliability coefficient of the scale was calculated as .889, .845 for the sub-dimension of "learning and renewal skills", .826 for "life and career skills" and .810 for "information, media and technology skills" (Anagün, Atalay, Kılıç & Yaşar, 2016). Table 3 shows the Cronbach Alpha values calculated in this study.

Table 3. Cronbach alpha values of the scale for self-efficacy perception towards 21st Century Skills

Dimensions	N	Cronbach's Alpha
Learning and Renewal Skills	16	,929
Life and Career Skills	18	,881
Information, Media and Technology Skills	8	,875
Scale for self-efficacy perception towards 21st century skills (in general)	42	,944

Semi-Structured Interview Form: Face-to-face interviews were conducted with the teachers as qualitative data to support the quantitative data in the study and a semi-structured interview form was used to record these interviews in writing. Quantitative data alone can establish a statistical relationship between variables, but qualitative data were also included, as it is generally considered that it cannot provide an in-depth understanding of the underlying mechanisms and causes of the observed patterns. The questions are designed in a way that will enable the participants to freely express their thoughts about STEM education and 21st century skills and to be guided to make examples. The interview form, which was finalized by taking the opinions of two field experts, consisted of 6 questions. It is aimed to convey the feelings and thoughts of the participants sincerely and in detail with the instructions such as “why” and “explain” in the content of the questions.

Analysis of Data

The quantitative data were analysed using the IBM SPSS Statistics 24 program. The arithmetic mean and standard deviation values of the scores obtained from the scales were used. In addition, the normality of the distribution of the data was examined whether it showed a normal distribution according to gender and seniority, and the appropriate parametric and non-parametric tests were preferred for binary and more than two variables to interpret the data. The changes in the scores obtained from the scales depending on gender and professional seniority were examined with the t-Test, Mann Whitney U test (MWU) and Kruskal Wallis-H test (KWH). In the study, p = 0.05 was accepted for the level of significance. In addition, Cohen’s calculation was used to determine the effect size in cases where there was variation between groups as a result of the t-test (Cohen, 1988). To examine the relationship between teachers’ self-efficacy perceptions towards 21^{st} century skills and STEM attitudes, the Spearman Rank Differences Correlation Coefficient was calculated, and the relationships between the overall scales and their sub-dimensions were examined.

Content analysis technique was used in the analysis of qualitative data. By examining the raw data obtained, key concepts were determined and the relationship between these concepts was examined and final codes and themes were created. Content analysis was carried out by two independent researchers using the codes created from the raw data. Two researchers independently analysed the qualitative data using codes derived from the raw data to assess inter-research consistency. They compared their findings and calculated the proportion of codes that both researchers identified. In instances of disagreement, the researchers engaged in discussions until a consensus was reached and a common decision was made. This process ensured that the analysis was conducted with a shared understanding and agreement between the researchers. Inter-research consistency was calculated by Miles and Huberman’s (1994) formula and found to be 88.4. The fact that the Miles and Huberman reliability coefficient is above 70 indicates that the agreement between the researchers is reliable (Miles & Huberman, 1994). In the study, the identities of the teachers were kept confidential, and the interview forms were coded as T1, T2, T3,...

Results

The findings obtained from quantitative and qualitative data in line with the objectives of the study are below.

RQ1: What is the level of science teachers’ self-efficacy perceptions towards 21st century skills, and STEM attitudes?

The general descriptive findings regarding the general and sub-dimensions of the scale for science teachers’ self-efficacy perception towards 21^{st} century skills are presented in Table 4. According to the arithmetic mean scores, it is observed that the answers given by the teachers to the propositions in the “Learning and Renewal Skills”, “Life and Career Skills” and “Information, Media and Technology Skills” sub-dimensions of self-efficacy perceptions towards 21^{st} century skills and in the general scale are at the "always" level, that is, at a high level. Teachers’ attitudes towards STEM were examined based on the arithmetic mean and standard deviation values for the overall scale and its sub-dimensions, and the descriptive findings are given in Table 5. Considering the average values, it is found that teachers’ STEM attitudes are at the level of "totally agree" in the sub-dimension of "STEM activities", at the level of "agree" in the sub-dimension of "lesson planning", and at the level of "totally agree" in the scale in general.

Table 4. Descriptive results of the scale for self-efficacy perception towards 21^{st} century skills

Dimensions	N	$\bar{x}$	SS
Learning and Renewal Skills	50	4,12	,516
Life and Career Skills	50	4,18	,423
Information, Media and Technology Skills	50	4,13	,560
Scale for self-efficacy perception towards 21^{st} century skills (in general)	50	4,14	,408

Table 5. Descriptive findings regarding the scores of teachers from the STEM attitude scale

Dimensions	N	x̄	SS
STEM Activities	50	4,25	,559
Lesson Planning	50	3,25	,747
STEM Attitude Scale (in general)	50	4,04	,479

RQ2: Is there a significant difference in science teachers' self-efficacy perceptions towards 21st century skills, and STEM attitudes according to gender and professional seniority?

The t-test results regarding whether the teachers' self-efficacy perceptions of 21st century skills differ according to the gender variable are presented in Table 6. It is found that the average scores of women in the general scale and all sub-dimensions are higher. However, the difference between the scores of female and male teachers is not statistically significant. In other words, there is no significant difference in the general and sub-dimensions of the scale according to the gender variable.

Table 6. Comparing teachers' self-efficacy perceptions of 21st century skills according to gender variable

Dimensions	Gender	N	x̄	SS	Sd	t	p
Learning and Renewal Skills	Female	25	4,18	,549			
	Male	25	4,06	,484	48	,819	,417
Life and Career Skills	Female	25	4,23	,434			
	Male	25	4,12	,413	48	,851	,399
Information, Media and Technology Skills	Female	25	4,14	,562			
	Male	25	4,13	,571	48	,094	,926
Scale for self-efficacy perception towards 21st century skills (in general)	Female	25	4,19	,421			
	Male	25	4,10	,398	48	,796	,430

p >,05

Table 7. Kruskal Wallis-h test results in which self-efficacy perceptions towards 21st century skills are compared according to the variable of professional seniority

Dimensions	Seniority	N	x̄	ss	SO	Sd	X^2	p
Learning and Renewal Skills	1-5 years	10	3,89	,464	19,65			
	6-10 years	13	4,20	,404	27,73			
	11-15 years	14	4,25	,449	29,32	3	3,107	,375
	16 years and above	13	4,05	,682	23,65			
Life and Career Skills	1-5 years	10	4,01	,441	19,05			
	6-10 years	13	4,18	,324	24,81	3		
	11-15 years	14	4,31	,303	30,32		3,544	,315
	16 years and above	13	4,15	,578	25,96			
Information, Media and Technology Skills	1-5 years	10	4,35	,634	31,00			
	6-10 years	13	4,22	,606	28,08	3		
	11-15 years	14	4,14	,424	24,68		4,050	,256
	16 years and above	13	3,88	,553	19,58			
Scale for self-efficacy perception towards 21st century skills (in general)	1-5 years	10	4,03	,367	21,25			
	6-10 years	13	4,19	,317	26,85	3		
	11-15 years	14	4,26	,316	29,29		2,191	,534
	16 years and above	13	4,06	,579	23,35			

The Kruskal Wallis-H test results on whether the teachers' self-efficacy perceptions of 21st century skills differ according to the variable of professional seniority are given in Table 7. According to these results, there is no significant difference in terms of the seniority variable in sub-dimensions "*Learning and Renewal Skills*" (X^2=3,107), "*Life and Career Skills*" (X^2=3.544), "*Information, Media and Technology Skills*" (X^2=4,050) and the overall scale (X^2=2.191) (p>0.05).

The t-test results on whether science teachers' attitudes towards STEM education differ according to the gender variable are presented in Table 8. According to the independent group's t-test results, there is a significant difference in favour of women between male and female teachers in the STEM attitude scale (t(48)=2.042, p<.05). According to the calculated Cohen's d value, this difference was determined to be moderate.

Table 8. T-test results comparing teachers' STEM attitudes according to gender variable

Dimensions	Gender	N	x̄	SS	Sd	t	p	d
STEM Attitude Scale (in general)	Female	25	4,17	,476				
	Male	25	3,91	,451	48	2,042	,047	0,57

The MWU Test results regarding whether the sub-dimensions of "STEM activities" and "lesson planning" of the STEM attitude scale differ according to the gender variable are presented in Table 9. According to the findings in the table, there is no significant difference in the sub-dimensions of the scale according to the gender variable.

Table 9. The results of the MWU Test, in which teachers' STEM attitudes were compared according to the gender variable

Dimensions	Gender	N	x̄	SS	SO	ST	U	p
STEM Activities	Female	25	4,37	,493	28,26	706,50	243,500	,177
	Male	25	4,13	,604	22,74	568,50		
Lesson Planning	Female	25	3,44	,656	28,28	707,00		
	Male	25	3,05	,792	22,72	568,00	243,000	,173

The results of the Kruskal Wallis-H Test, which was conducted to determine the effect of teachers' professional seniority on STEM attitudes, are given in Table 10. According to these results, there is no significant difference in teachers' STEM attitudes and sub-dimensions in terms of seniority variable (p>0.05).

Table 10. The results of the Kruskal Wallis-H Test, in which teachers' STEM attitudes are compared according to the variable of professional seniority

Dimensions	Seniority	N	x̄	ss	SO	Sd	X^2	p
Lesson Planning	1-5 years	10	3,36	,514	27,60			
	6-10 years	13	3,44	,664	28,08			
	11-15 years	14	3,30	,553	26,68	3		,460
	16 years and above	13	2,92	1,066	20,04		2,584	
STEM Activities	1-5 years	10	4,45	,430	29,70			
	6-10 years	13	4,09	,715	23,31	3		
	11-15 years	14	4,37	,410	27,68		2,177	,537
	16 years and above	13	4,12	,586	22,12			
STEM Attitude Scale (in general)	1-5 years	10	4,22	,370	30,80			
	6-10 years	13	3,95	,570	23,46	3		
	11-15 years	14	4,15	,290	29,68		5,368	,147
	16 years and above	13	3,87	,579	18,96			

RQ3: Is there a relationship between science teachers' self-efficacy perceptions towards 21st century skills, and STEM attitudes?

The results of Spearman Correlation analysis to determine a relationship between teachers' self-efficacy perceptions towards 21st century skills, and STEM attitudes are given in Table 11. According to the results of the analysis, it was determined that there is a high level of positive correlation between the scale for self-efficacy perception towards 21st century skills and "Learning and Renewal Skills" ($r_{spearman}$=,877), a high level of positive correlation between the scale and "Life and Career Skills" ($r_{spearman}$=,891), and a moderate positive correlation relationship between the scale and "Information, Media and Technology Skills" ($r_{spearman}$=,636). It was found that the highest relationship among the sub-dimensions of the scale for self-efficacy perceptions towards 21st century skills is between "Learning and Renewal Skills" and "Life and Career Skills" ($r_{spearman}$=.683; $p<.01$).

Table 11. Spearman Correlation analysis results for the relationship between self-efficacy perception towards 21st century skills, and STEM attitude

Dimensions	N	x̄	SS	1	2	3	4	5	6	7
1. Learning and Renewal Skills	50	4,12	,516	1						
2. Life and Career Skills	50	4,18	,423	,683**	1					
3. Information, Media and Technology Skills	50	4,13	,560	,394**	,417**	1				
4. Scale for self-efficacy perception towards 21st century skills	50	4,14	,408	,877**	,891**	,636**	1			
5. STEM Activities	50	4,25	,559	,281*	,366**	,441**	,428**	1		
6. Lesson Planning	50	3,25	,747	_	_	_	_	_	1	
7. STEM Attitude Scale	50	4,04	,479	,327*	,421**	,433**	,465**	,923**	,333*	1

*p<.05, **p<.01

It is observed that there is a low and positive correlation between the STEM attitude scale and the "Lesson Planning" sub-dimension ($r_{spearman}$=.333; $p<.05$), and a high and positive correlation between the scale and "STEM activities" sub-dimension ($r_{spearman}$=.923; $p<.01$).

A moderately significant and positive relationship was found between the STEM attitude scale and the scale for self-efficacy perception towards 21st century skills ($r_{spearman}$=465). In addition, it was found that there is a moderate positive correlation between the STEM attitude scale and the scale for self-efficacy perception towards 21st century skills "Life and Career Skills" sub-dimension ($r_{spearman}$=421), a moderate relationship between the scale and "Information, Media and Technology Skills" sub-dimension ($r_{spearman}$=433), and a low-level positive correlation between the scale and the "Learning and Renewal Skills" sub-dimension ($r_{spearman}$=327). Similarly, it is clear that there are positive and significant relationships at different levels between the scale for self-efficacy perception towards 21st century skills and its sub-dimensions, and the STEM attitude scale and the "STEM activities" sub-dimension (*p<.05; **p<.01)

RQ4: What are science teachers' views on 21st century skills and STEM education?

In the analysis of the qualitative data, the codes were determined and the participants' views on 21st century skills were evaluated from these codes, and the themes of classification of these skills, activities for gaining them, their importance for students and teachers' proficiency level were formed. Table 12 shows the findings.

Table 12. Classification and activities for 21st century skills, the importance of these skills for students and the level of proficiency of teachers

Classification	f	Activities	f	Importance of these skills for students	f	The level of proficiency	f
Creative thinking	20	In-class activity	12	Adapting to society	10	I am sufficient	23
Technology literacy	19	Different teaching techniques	11	Necessary for our future	9	I'm partially sufficient	16
Critical thinking	19	Research and projects	7	The requirements for 21st century	8	I'm not sufficient	11
Ability to access information	16	Technology use	6	Ability to solve problems	8		
Problem-solving skill	16	Using different perspectives	6	Social relations	4		
Information literacy	15	Group work	6	Growing competent individuals	3		
Imagination	11	Problem-solving activity	4	Ability to analyse	3		
Science literacy	8	Active participation activity	4				
Time management	6	Social activities	4				
Collaborative work	5	For new learning	4				
Effective communication	4	Learning by doing	3				
Media literacy	4	Communication	3				
Analytical thinking	4	Drama	2				
Social skills	3	Three-dimensional model	1				
Reflective thinking	3						
Innovative thinking	3	I don't do activities	5				

Science teachers classified 21st century skills as creative thinking, technology literacy, critical thinking, problem-solving, information literacy, science literacy, media literacy, collaborative work, effective communication, etc. The teachers stated that they had activities (activities involving different teaching techniques, project work, use of technology, group work, problem-solving, drama, and three-dimensional model development) during the course to help students gain these skills. On the other hand, five teachers stated that they did not have an activity to develop these skills. Participants stated that 21st century skills are important for students in terms of adapting to society, being a necessity of the century, solving problems, social relations, being competent individuals and making analysis. In addition, 21 of the participating teachers stated that they were at a sufficient level, 16 of them at a partially sufficient level, and 13 teachers stated that they were insufficient. Examples of teachers' statements on the themes of classification of 21st century skills, activities for gaining these skills, their importance for students, and teachers' proficiency level are given below:

> *T14: Creative thinking, critical thinking, group work and innovation can be counted among the 21st century skills. When the individual has these skills, he can easily take action in case of a problem, so it is important.*
> *T22: Yes, I do, because the time we are in forces us to use them anyway. I try to develop these skills by using many techniques such as brainstorming, the six hats technique, and discussion with my students.*
> *T42: Yes, it is important. Thanks to these skills, we keep up with society. It is also important for the next generation. Individuals should have these skills while solving their problems. I make in-class activities to gain these skills. I give importance to group work where they can use different perspectives and provide new learning.*
> *T38: I cannot say that I am completely sufficient, but I use the skills that I think I have.*

The views of the participating teachers on STEM education were analysed and the themes of activities, positive aspects, negative aspects, and teachers' STEM education proficiency levels were created in this context. Table 13 shows the findings.

Table 13. The activities carried out for STEM education, the positive and negative aspects of this education and the proficiency level of the teachers

Activities	f	Positive aspects	f	Negative aspects	f	The level of proficiency	f
End of unit activities	6	Keeps students active	15	Cost	7	I am sufficient	25
Activities that produce products	5	Provides permanent learning	9	Time	7	I'm partially sufficient	15
I design an activity suitable for the topic	4	Provides effective learning	7	It cannot be applied to all subjects	4	I'm not sufficient	10
Activities related to daily life	4	Educate individuals with today's skills	7	It is not suitable for the exam system	4		
Science applications events	4	It encourages production	5	Inadequacy of teachers	3		
Embodiment activities	4	It helps to cope with daily problems	4	Inequality of facilities in schools	3		
Curriculum-friendly activities	3	It develops different ways of thinking	4	Physical deficiencies	3		
Original designs related to science	3	It provides new production	3	It's hard to plan	2		
Laboratory studies	1	It leads to engineering	3	Individual differences among students	2		
Project studies	1	It provides learning by doing	3	Implementation difficulty	1		
Modelling activities	1	It finds different solutions	2				
		Developing technology	2				
I don't do activities	10	Motivating	1				

The majority of the participants (f: 40) stated that they tried to include STEM education practices in their lessons. In this sense, they stated that they carried out end-of-unit activities prepared according to the curriculum, activities that can be developed, appropriate to the subject, related to daily life, and original design. On the other hand, the other teachers (f: 10) stated that s/he did not include STEM education practices by displaying a negative attitude towards STEM education for various reasons such as lack of opportunity, time limitation and cost. As the positive aspect of STEM education, skill development has been emphasized with the code of raising individuals who are suitable for the needs of the age, together with its positive effects on active, permanent, effective learning and learning by doing experience. In addition, positive effects such as encouraging production, solving daily life problems, providing different thinking, directing engineering and technology development are listed. As the negative aspects of STEM education, it is stated that it cannot be applied to every subject, especially the cost and time problems, not being suitable for the exam system, inadequacy of teachers, physical inadequacies, planning and implementation difficulties. In addition, 24 of the participating teachers stated that they were at a sufficient level, 14 of them at a partially sufficient level, and 12 teachers stated that they were insufficient for STEM education. Examples of teachers' statements on the themes of the activities related to STEM education, the positive and negative aspects of this education and the level of proficiency of the teachers are given below:

> *T31: It is the product design process. Entrepreneurship provides active participation in the product design process, but it may not be suitable for every subject.*
> *T29: Since the student produces something new, he/she will feel successful and will do more research and participate in the study to go one step further. In STEM education, there is a product that every student can create. In this way, it is ensured that students with different intelligence types participate in the lesson.*
> *T20: It is science, mathematics and engineering education. Students are more interested in the lesson by providing permanent learning in such activities. It is difficult to plan such activities, I think that the curriculum and examination system are not appropriate.*
> *T40: Yes, I feel it. Yes, I'm trying to get it done on new topics. For example, in the classrooms, I want students to think about an illness and design accordingly. For example, like an invention such as breathing easily…*
> *T22: I do not find myself sufficient in this field, I think that I should take STEM education more comprehensively. I cannot apply STEM activities due to the lack of opportunities.*

Discussion and Conclusion

This study examined secondary school science teachers' self-efficacy perceptions towards 21st century skills and attitudes towards STEM education in terms of gender and professional seniority variables. The relationship between teachers' self-efficacy perceptions towards 21st century skills and STEM attitudes was tried to be revealed. According to the quantitative data of the study, teachers' self-efficacy perceptions of 21st century skills are at a high level. In other words, it was determined that teachers' self-efficacy perceptions were high in terms of *learning and renewal skills*, *life and career skills*, and *knowledge, media and technology skills*, which are the sub-dimensions of the scale. According to this finding, it can be said that teachers can develop original and creative ideas in terms of learning and renewal skills, try different ways to solve the problems they encounter, and have analysis-synthesis skills (Lavi, Tal & Dori, 2021). In the context of life and career skills, it can be said that teachers have a positive perception of themselves in terms of flexibility, effective communication, adaptability, and taking responsibility (Kan & Murat, 2018). It can be said that teachers who have a high level of self-efficacy perception of knowledge, media and technology skills have positive perceptions of using technology effectively, solving problems, and collecting and analysing information (Park, Kim & Park, 2021). Supporting these findings, Kan and Murat (2018) determined that science teacher candidates have a high level of self-efficacy perceptions of 21st century skills. The qualitative data of the study partially support these findings. While 78% of the participating teachers felt partially sufficient or sufficient in terms of 21st century skills, 22% stated that they were insufficient. Teachers have shown that they have the necessary knowledge by classifying skills such as creativity, problem-solving, communication, collaborative work, information, technology and media literacy as 21st century skills. The majority of the teachers emphasized that 21st century skills are important for students to adapt to society as a requirement of the century, to have the necessary competencies and to solve their problems, and stated that they include activities for these skills in their lessons. 5 teachers who do not consider themselves sufficient in this sense stated that they do not have activities related to skills. According to Zakariya (2020), teachers' self-efficacy is a factor that determines teaching practices. A teacher with low self-efficacy towards 21st century skills will not be able to attempt such practices as a reflection of his/her disbelief in students and their abilities (Geng et al., 2019). In the study, it was determined that science teachers' self-efficacy perceptions towards 21st century skills did not differ according to gender and professional seniority variables. Although there is no study in the literature examining the change of teachers' self-efficacy perceptions of 21st century skills according to gender, there are findings showing that teacher self-efficacy both changes (Dilekli & Tezci, 2020) and does not change (Sulaiman & Ismail, 2020) according to gender. However, there are also reports that self-efficacy towards 21st century skills differs depending on the seniority of the teachers (Gürültü, Aslan & Alçı, 2019).

In the other part of the study, it was determined that the attitudes of science teachers towards STEM education were positive and at a high level. The positive attitude of teachers is important in reflecting STEM education in teaching environments. Attitude also affects teachers' self-efficacy (Thibaut, et al., 2018), and teachers with positive attitudes can enjoy STEM teaching and contribute to STEM learning outcomes (Hackman, Zhang & Jingwen He, 2021). The opinions of science teachers in the study also support that their STEM attitudes are positive. The majority of the participating teachers stated that they included STEM applications in their lessons by listing the positive effects of STEM education such as keeping students active, providing effective and permanent learning, providing skill development and productivity, making them think differently and directing them to engineering. Similarly, in the literature, there are positive opinions of teacher candidates (Sarı, Çelik, Pektaş & Yalçın, 2022) and teachers (Sarı & Yazıcı, 2019) that STEM education will make significant contributions to science education and students' knowledge and skill development. In addition, 50% of the teachers see themselves as self-sufficient and 30% as partially sufficient for STEM education. These qualitative findings are consistent with the result that teachers have high STEM attitude levels. On the other hand, some of the participating teachers showed that they exhibited negative attitudes towards STEM by listing the negative aspects of STEM education as cost, time, non-compliance with exam systems, teacher inadequacy, and physical inadequacies. In their study, Sarı, Duygu, Şen, and Kırındı (2020) reported situations such as time, cost, class size, exam system, and physical inadequacies as difficulties for STEM. The negative opinions of the teachers in the study are also compatible with the opinions of the teachers who do not see themselves as sufficient at the 20% level and do not include STEM activities in the lessons.

In the study, a moderately significant positive relationship was found between the attitudes of science teachers towards STEM education and their self-efficacy perceptions towards 21st century skills. The results revealed that there is a positive and significant relationship between the STEM attitude scale and the sub-dimensions of the scale for self-efficacy perception towards 21st century skills, namely "life and career skills", "knowledge, media and technology skills" and "learning and renewal skills". Similarly, positive significant relationships were found between the scale for self-efficacy perception towards 21st century skills and its sub-dimensions and the "STEM activities” sub-dimension of the STEM attitude scale. Teachers with positive attitudes towards STEM education also have high self-efficacy perceptions towards 21st century skills. In this case, it can be said that teachers’ STEM attitudes and self-efficacy perceptions towards 21st century skills can mutually affect each other positively. Similarly, Akcanca (2020) determined that teacher candidates’ attitudes towards STEM education have a significant relationship with their perceptions towards 21st century skills. To be a science and technology innovator in the 21st century technology era and to take part in the competitive world, it is important to educate students who are STEM literate and competent in 21st century skills. It is predicted that this self-efficacy will be possible with effective STEM education (Sarı, Pektaş, Şen & Çelik, 2022). Thibaut et al. (2018) determined that teachers’ STEM teaching practices are positively related to STEM attitudes. Therefore, this positive attitude of teachers is important in improving STEM education. In addition, if teachers are going to include teaching practices that will improve their students’ 21st century self-efficacy, it will be important for them to have this self-efficacy themselves (Beswick & Fraser, 2019).

In conclusion, this study shows that science teachers’ attitudes towards STEM education and their self-efficacy perceptions of 21st century skills are related to each other. Teachers’ self-efficacy perception of 21st century skills will positively affect STEM attitudes and increase the quality of STEM teaching practices. Thus, students’ STEM attitudes can improve with effective STEM practices, and their STEM learning can improve and contribute to the development of 21st century competencies.

Recommendations

According to the results of the research, it can be ensured that teachers have a positive attitude towards STEM by developing their 21st century skills self-efficacy perceptions. This study is limited to 50 science teachers. The research can be modelled to study teachers in other STEM disciplines. In addition to the measurement tools used in this study, teachers’ classroom teaching practices can also be evaluated. The results will be valuable as a wealth of literature together with this study.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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