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Investigation of the Relationship Between Science Motivation and the 21st Century Skill Levels of Secondary School Students

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Abstract

This study aimed to comprehensively examine the relationship between science motivation and the 21st-century skill levels of secondary school students. The study was conducted according to the quantitative methodology using the correlational survey method. The convenience sampling approach was adopted in the study. The study group was analyzed in terms of gender and grade level variables. Additionally, the measurement models created for middle school students' "Science Motivation" (SM) and "21st-Century Skills" (21st-CS), as well as the theoretical structural model was created. The study included 507 secondary school students (252 females, 255 males). Based on the results of the study, reviewing SM scale and its sub-dimensions, there was no significant difference between genders in the dimensions except for "Intrinsic Motivation." In addition, a significant difference was found between the grade levels in terms of (SM) level. There was no significant difference in the different sub-dimensions of the 21st-CS according to gender; however, a significant difference was found in terms of grade levels. Generally, positive correlations were found between the sub-dimensions of the SM scale and the sub-dimensions of the 21st-CS levels. Additionally, there is a statistically significant relationship between science motivation and cognitive skill, affective skill, and socio-cultural skill. These findings emphasize that science education and motivation in this field may play a significant role in the development of 21st-CS.

Keywords: Science motivation, 21st-century skills, secondary school students, path analysis

Introduction

Generations raised in a constantly changing and accelerating world should have the skills to keep up with these developments and changes. The skills that generations should master evolve with each succeeding century. Like other eras, the 21st-century has brought about its requirements. This has driven human beings to use the 21st-century skills in every field in which they interact with their environment or each other. This also necessitates changes in educational institutions that prepare generations for the future (Smith & Hu, 2013). Nowadays, the 21st-century skills are used to explain the social order referred to as the information society. This is because the 21st-century skills express the harmony of knowledge and skills (Dede, 2010). The content of the 21st-century skills has been described in different theoretical frameworks in the literature (Binkley et al., 2012). Therefore, it was necessary to classify these skills in terms of some shared characteristics. One of the main headings regarding the classification of the 21st-century skills was expressed as "life and career skills, learning and innovation skills, and information and media technology skills" (P21, 2007). According to another categorization, these skills included "using tools interactively (using language, writing, technology, symbols, etc.), interacting in heterogeneous groups (establishing good relationships with others, cooperating, etc.), acting autonomously (defending rights, interests, decisions, boundaries, etc.)" (OECD, 2005, cited by Dede, 2010). The MoNE (2011) categorized the skills students should have in the 21st century in 4 groups as "ways of thinking, ways of working, working tools, and integration into the world". The 21st-century skills are generally expressed as creative thinking, critical thinking, problem-solving, effective communication, digital competencies,

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innovation, productivity, openness to cooperation, having social and cultural skills, and self-direction, etc. (Ananiadou & Claro, 2009; Binkley et al., 2012; MoNE, 2011; NRC, 2011; OECD, 2005, cited by Dede, 2010; P21, 2007; Smith & Hu, 2013; Van Laar et al., 2017). Examining all the skills mentioned in the literature, we observe that there are skills from different fields in addition to cognitive skills. In this respect, we can also classify the 21st-century skills as "cognitive skills, interpersonal skills, and individual skills" (NRC, 2011). Social, communicative, and affective skills are also categorized here in addition to cognitive skills. In the categorization of the 21st-century skills, we observe affective characteristics such as self-discipline, independent learning ability, flexibility and adaptability, self-awareness, perseverance, personal motivation, compassion, honesty, and self-respect (UNESCO, 2016) under the heading of individual skills (NRC, 2011).

When constructing learning environments for the acquisition of the 21st-century skills, all elements of the learning environment (teacher, student, program, material, etc.) should be structured harmoniously. Therefore, all these elements should be considered when designing educational policies for the acquisition of the 21st-century skills. The individual characteristics of the student, one of the elements mentioned here, are essential for the development level of these skills. Accordingly, motivation is one of the individual characteristics affecting the development of 21st-century skills (Jannah et al., 2020). Motivation refers to an individual's willingness to initiate, continue, and complete a task (Hellriegel et al., 2001; Taloo, 2007). Therefore, motivation plays an important role in the acquisition of the 21st-century skills. Highly motivated individuals may be more determined and enthusiastic about acquiring and implementing these skills. Furthermore, it can be argued that motivation significantly affects the implementation of these skills.

Motivation is the power to drive an individual's behavior towards a goal, to sustain this behavior, and to steer it (Pintrich & Schunk, 2002). Motivation to learn fosters the learner's active participation in the educational process and the tendency to respond to a specific need or desire as a mental force (Pintrich & Schunk, 2002; Sternberg & Williams, 2009). Therefore, it positively affects academic achievement, which helps us to evaluate whether the teaching process is successful or not (Alderman, 2004; Koballa & Glynn, 2007; Olsen & Chernobilskt, 2016; Pintrich & Schunk, 2002). Accordingly, highly motivated students are determined to participate in the learning process actively, can resist difficulties, have self-regulation skills, and are persistent in achieving goals (Deci & Ryan, 2000). Besides, these students often concentrate on deep learning and seek to fully grasp the topics rather than surface learning (Biggs, 1987).

Science has been defined by students as a subject difficult to understand (Millar, 1991; Okumuş, Koç & Doymuş, 2019; Özdilek, Okumuş & Doymuş, 2018). One of the main reasons underlying this is the abstract nature of the subject area (Millar, 1991). Johnstone (1991) attributes the main reason for the difficulty in learning science to teaching methods. Therefore, it is essential that students are highly motivated in the subject areas of science, which are known to be challenging to understand. Science motivation refers to students' interest in, evaluation of, and intrinsic or extrinsic driving forces for science learning. This motivation reflects students' interest in science, the value they attach to education in this field, and their willingness to put effort into it (Wigfield & Eccles, 2000). Students' interest and achievement in science are directly related to their motivation. In particular, positive science experiences and effective teacher interactions can increase students' motivation toward science education (Osborne et. al., 2003). Therefore, designing science education to support students' motivation contributes to their scientific literacy, promoting them to become more conscious and eager to make career choices in the field of science.

It would not be wrong to say that motivation for learning science plays a critical role in acquiring the skills needed in the 21st-century. This is because students' interest in science supports their acquisition of the 21st-century skills such as reflection, problem-solving, critical thinking, and collaboration (National Research Council, 2012). These skills are increasingly essential in our knowledge-based society and enable students to succeed in their future careers and everyday lives (Trilling & Fadel, 2009). Therefore, increasing motivation toward science learning is thought to help students acquire these fundamental skills and participate as active and conscious individuals in the dynamic and rapidly changing world of the 21st-century (Bybee, 2010). Accordingly, the level of the relationship between the 21st-century skills and motivation to learn science, one of the factors affecting these skills, among students, can be considered an important research topic. However, in this study, a model regarding 21st-century skills and science motivation was created.

The aim of this study is to comprehensively examine the relationship between secondary school students' science motivation and 21st-century skill levels and then to create a model of 21st-century skills and science motivation. In this regard, the study examined the relationship between science motivation and 21st-century skills and demographic characteristics (i.e. gender and grade level), as well as the relationship between 21st-century skills and science motivation. Finally, a model was created with 21st-century skills and science motivation. Problem statements of the study were as follows:

1. Is there a difference between the science motivations of secondary school students according to their demographic characteristics?1.1Is there a significant difference between secondary school students' motivation to learn science according to gender?
2. Is there a significant difference between secondary school students' motivation to learn science according to grade level?
   - 1.1 Is there a difference between the 21st-century skill levels of secondary school students according to their demographic characteristics?
   - 1.2 Is there a significant difference between the 21st-century skill levels of secondary school students according to gender?
   - 1.3 Is there a significant difference between the 21st-century skill levels of secondary school students according to grade level?
3. Is there a relationship between the 21st-century skill levels of secondary school students and their science motivation?
4. How is the model fit goodness of the measurement models created for middle school students' science motivation and 21st-century skills?
5. How is the model fit goodness of the structural model that predicts middle school students' science motivation and 21st-century skills?

Method

Research Design

The study was conducted according to the quantitative methodology using the correlational survey method. The correlational survey model is a type of general screening models. It is a research approach that aims to determine whether there is a simultaneous change between two or more variables and the extent of this change (Fraenkel and Wallen, 2009; Karasar, 2005).

Population and Sample

This study examined secondary school students enrolled in public schools in Malatya province during the 2019-2020 academic year. The convenience sampling approach was adopted in the study. The study group was analyzed in terms of gender and grade level variables. The distribution of students according to their gender and grade level was analyzed in the study, and the results are presented in Table 1.

Table 1: Descriptive Statistics of the Study Group

Variable	*Category*	*Frequency*	*Percentage (%)*
Gender	Female	252	49.7
	Male	255	50.3
Grade Level	5th Grade	114	22.3
	6th Grade	83	16.2
	7th Grade	115	22.5
	8th Grade	200	39.1

According to the descriptive statistics in Table 1, the study group consisted of 507 secondary school students. Among these students, 252 were female (49.7%), and 255 were male (50.3%). Reviewing the distribution by grade level, 114 students were in 5th grade (22.3%), 83 in 6th grade (16.2%), 115 in 7th grade (22.5%), and 200 in 8th grade (39.1%).

According to the gender distribution of the study group in Table 1, it was observed that the number of male and female students was almost equal. The gender variable is significant in terms of understanding the demographic characteristics of the study group. Considering the grade level variable of the study group, it was determined that 8th-grade students were the majority. However, in our study, there are a sufficient number of students from each grade level at the secondary school level.

Data Collection Tools

Science Motivation Scale

The Science Motivation Scale was developed by Glynn, Brickman, Armstrong and Taasoobshirazi (2011) and adapted to Turkish by Isin (2019). It consists of 22 items. The scale has a five-factor structure. These factors are Intrinsic Motivation (IM), Career (Ca), Self-Determination (CD), Self-Efficacy (SE), and Grade Motivation (GM). The scale items are scored between "Never" and "Always" in a 5-point Likert-type format. The scale was administered to secondary school students. The Cronbach's alpha value, which refers to the reliability coefficient of the scale, was calculated by the developer of the scale as *0.83*. Looking at its value, it can be considered a reliable scale.

The Intrinsic Motivation (IM) factor consists of three items, which are I01, I03, and I15. The Career Motivation (CM) factor consists of five items, which are I07, I10, I12, I20, and I22. The Self-Determination (SD) factor consists of four items, which are items I05, I06, I11, and I19. The Self-Efficacy (SE) factor consists of five items, which are I09, I13, I14, I16,

and I18. Finally, the Grade Motivation (GM) factor consists of four items, which are I02, I04, I17, and I21. Factor scores were calculated for each factor by averaging the sum of the corresponding items. These calculations were made to obtain scale scores and factor scores.

According to the results of the reliability analysis conducted for the sub-dimensions of the Science Motivation Scale, the Cronbach's alpha value of the Intrinsic Motivation (IM) sub-dimension was found as *.500, .649* for the Grade Motivation sub-dimension, *.674* for the Self-Determination sub-dimension, *.835* for the Career Motivation sub-dimension, and *.794* for the Self-Efficacy sub-dimension. Based on all items of the scale, the overall Cronbach's alpha value was calculated as *.893.* These results show that the scale has a high overall internal consistency; however, the IM sub-dimension draws attention with a relatively low internal consistency value (Field, 2013; Hair et al., 2010; Tabachnick & Fidell, 2007).

The 21st Century Skills Scale

The" 21st Century Skills Scale" developed by Kang, Kim, Kim, and You (2012) and adapted to Turkish by Karakas (2015) was designed to evaluate the 21st century skills of secondary school students. As a result of the Turkish adaptation studies, the scale consisting of 32 items was divided into three main factors: Cognitive Skills (CS), Affective Skills (AS), and Socio-Cultural Skills (SCS). Items are rated from "Strongly Disagree" to "Strongly Agree" in a 5-point Likert-type format. Scale scores are calculated by calculating the arithmetic mean of the items. The internal consistency coefficients for the sub-dimensions were calculated by the adaptor of the scale as *.77, .70*, and *.67*, respectively.

Cognitive Skills (CS): This factor aims to evaluate students' cognitive skills and includes 12 items. The factor score is calculated by averaging the total score of these 12 items.

Affective Skills (AS): This factor aims to evaluate students' affective skills and includes 10 items. The factor score is calculated by averaging the total score of these 10 items.

Socio-Cultural Skills (SCS): This factor aims to evaluate the socio-cultural skills of students and includes 10 items. The factor score is calculated by averaging the total score of these 10 items.

The total score of the scale is calculated by averaging the scores of all items. In addition to these calculations, necessary calculations were made for scale factors and total scores through a special program.

According to the results of the reliability analysis, the Cronbach's alpha value of the CS sub-dimension was found to be *.749* (N=12). In addition, the Cronbach's alpha value was *.763* (N=10) for the AS sub-dimension and *.717* (N=10) for the SCS sub-dimension. Based on all items of the scale, the overall Cronbach's alpha value was calculated as *.887* (N=32). These results show that the sub-dimensions analyzed, and the overall scale have an internal consistency from moderate to high. In particular, the fact that the overall Cronbach's alpha value of the scale was *.887* indicates that the scale has a high internal consistency in general (Field, 2013; Hair et al., 2010; Tabachnick & Fidell, 2007). These findings show that the reliability of the scale and its sub-dimensions is generally acceptable.

Data Collection

The scales used were applied simultaneously to secondary school students in the 2019-2020 academic year.

Data Analysis

The findings were obtained through appropriate statistical methods to address the sub-objectives identified within the scope of the study. Whether the continuous variables in the data set were normally distributed was evaluated by skewness and kurtosis values. According to the literature, the skewness and kurtosis values between -2 and +2 indicate the data set has a normal distribution (George & Mallery, 2010). The values obtained in this study were in this range. Moreover, a sample size greater than 30 supports the usability of parametric tests (Lumley et al., 2002). Additionally, parametric tests are more advantageous in terms of statistical power compared to non-parametric tests (Norman & Streiner, 2008). For these reasons, parametric tests were preferred for testing the hypotheses. The independent sample t-test was conducted to determine whether there were significant differences between science motivation and 21st-century skills according to gender. The independent sample t-test is an ideal method for testing whether there is a significant difference between the means of two independent groups (Field, 2013). One-way Analysis of Variance (ANOVA) was carried out to determine the differences between students' science motivation and 21st-century skill levels according to their grade levels. ANOVA is used to determine whether there are significant differences between the means of three or more groups (Hair et al., 2010). The Pearson correlation coefficient was calculated to obtain information about the presence and severity of the relationship between students' science motivation and 21st-century skill levels. The Pearson correlation coefficient is used to determine the strength and direction of the linear relationship between two continuous variables (Field, 2013). All analyses were conducted at the 95% confidence interval and according to the significance level of $p<0.05$. Additionally, the measurement models created for middle school students'

Science Motivation (SM) and 21st Century Skills (21st-CS) and the theoretical structural model have been examined in this study. Analyses were conducted using the lavaan (v. 0.6-16) and semPlot (v. 1.1.6) packages of the R program. For hypothesis tests, a *p<.05* alpha significance level was adopted. The 2nd level confirmatory factor analysis (CFA) was used to test the measurement models, and the Maximum Likelihood (ML) method was used for structural equation model analysis to test the structural model.

Findings

Investigation of Science Motivation According to Demographic Variables Science Motivation Levels of Secondary School Students According to Gender

It was examined whether there was a significant difference between secondary school students' science motivation according to gender. In this context, students were administered the Science Motivation Scale. The sub-dimensions in the scale were defined as Intrinsic Motivation (IM), Career Motivation (CM), Self-Determination (SD), Self-Efficacy (SE), and Grade Motivation (GM). The descriptive statistics and t-test results of the secondary school students obtained from the science motivation scale are presented in Table 2.

According to Table 2, looking at the t-test results for Science Motivation Level (Total), it was observed that the mean score of female students was *4.10 (sd=0.59)* while the mean score of male students was *4.16 (sd=0.57)*. The difference between the two groups was not statistically significant, *t(501.159) = -1.141, p > .05*. Examining the t-test results for the Intrinsic Motivation (IM) sub-dimension, it was seen that the mean scores of female and male students were *3.91 (sd=0.84)* and *4.06 (sd=0.77)*, respectively. The difference between the two groups was statistically significant, *t(486.687) = -2.164, p < .05*. This result indicated that male students had higher levels of intrinsic motivation compared to female students. Looking at the t-test results for the Career Motivation (CM) sub-dimension, it was observed that the mean score of female students was *4.52 (sd=0.59)*, while the mean score of male students was *4.49 (sd=0.62)*. Nevertheless, this difference between the two groups was not statistically significant, *t(486.462) = 0.561, p > .05*. When the t-test results for the Self-Determination (SD) sub-dimension were analyzed, it was observed that the mean scores of female and male students were *4.12 (sd=0.67)* and *4.13 (sd=0.69)*, respectively. This difference between the two groups was not statistically significant, *t(478.902) = -0.126, p > .05*. According to the t-test results for the Self-Efficacy (SE) sub-dimension, the mean score of female students was *3.75 (sd=0.95)*, and the mean score of male students was *3.86 (sd=0.94)*. The difference between the two groups was not statistically significant, *t(473.846)=-1.265, p> .05*. Considering the t-test results for the Grade Motivation (GM) sub-dimension, the mean scores of female and male students were *4.23 (sd=0.71)* and *4.26 (sd=0.76),* respectively. The difference between the two groups was not statistically significant, *t(475.862)=-0.494, p> .05*.

Table 2: The Descriptive Statistics and T-test results of the Science Motivation Scale

Variable	*Gender*	*N*	*Mean*	*Standard Deviation*	*t*	*sd*	*p*
Science Motivation Level (Total)	Female	251	4.10	0.59	-1.141	501.159	.254
	Male	253	4.16	0.57			
Intrinsic Motivation (IM)	Female	248	3.91	0.84	-2.164	486.687	.031*
	Male	243	4.06	0.77			
Career Motivation (CM)	Female	242	4.52	0.59	0.561	486.462	.575
	Male	247	4.49	0.62			
Self-Determination (SD)	Female	239	4.12	0.67	-0.126	478.902	.900
	Male	242	4.13	0.69			
Self-Efficacy (SE)	Female	237	3.75	0.95	-1.265	473.846	.207
	Male	239	3.86	0.94			
Grade Motivation (GM)	Female	242	4.23	0.71	-0.494	475.862	.622
	Male	239	4.26	0.76			

Note: *p<.05

Science Motivation Levels of Secondary School Students According to Grade Level

Science motivation levels of students and possible differences in intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation according to their grade levels were examined by One-Way ANOVA analysis. The descriptive statistics and One-Way ANOVA results of students obtained for the total score and factors of the science motivation scale are presented in Table 3.

According to Table 3, the mean science motivation level was *4.33 (sd= .48)* for the 5th grade students, *4.35 (sd = .50)* for the 6th grade students, *4.04 (sd = .62)* the 7th grade students, and *3.97 (sd = .59)* for the 8th grade students. A significant difference was found between grade levels in terms of science motivation (SM) level, $F\ (3.505) = 14.84,\ p< .05$. According to the Bonferroni results, there was a significant difference between 5th grade and 7th grade and between 5th grade and 8th grade *(p< .05)*. Moreover, significant differences were found between 6th grade and 7th grade and between 6th grade and 8th grade *(p< .05)*. The Intrinsic Motivation (IM) values were examined and the mean intrinsic motivation was found as *4.24 (sd = .68)* among 5th grade students, *4.09 (sd = .86)* among 6th grade students, *3.94 (sd = .84)* among 7th grade students, and *3.84 (sd = .80)* among 8th grade students. There were significant differences between grade levels in terms of intrinsic motivation, $F\ (3.491) = 6.45,\ p< .05$. According to Bonferroni test results, significant differences were found between 5th grade and 7th grade and between 5th grade and 8th grade (p< .05). Regarding career motivation (CM) values, the mean career motivation was found as *4.65 (sd= .44)* for

Table 3: The Descriptive Statistics and ANOVA results of the Science Motivation Level

Assessment	*Grade Level*	*N*	*Mean*	*sd*	*F*	*df1, df2*	*p*
SM	5th Grade	114	4.33	.48	14.84	3, 505	.000*
	6th Grade	80	4.34	.50			
	7th Grade	115	4.04	.62			
	8th Grade	200	3.97	.59			
IM	5th Grade	109	4.24	.68	6.45	3, 491	.000*
	6th Grade	79	4.09	.86			
	7th Grade	113	3.94	.84			
	8th Grade	194	3.84	.80			
CM	5th Grade	110	4.65	.44	6.21	3.490	.000*
	6th Grade	79	4.64	.51			
	7th Grade	113	4.42	.66			
	8th Grade	192	4.40	.68			
SD	5th Grade	110	4.65	.44	6.21	3.490	.000*
	6th Grade	79	4.64	.51			
	7th Grade	113	4.42	.66			
	8th Grade	192	4.40	.68			
SE	5th Grade	111	4.07	.83	11.59	3.477	.000*
	6th Grade	75	4.11	.80			
	7th Grade	107	3.80	.96			
	8th Grade	188	3.52	1.00			
GM	5th Grade	108	4.46	.58	12.56	3.482	.000*
	6th Grade	78	4.53	.56			
	7th Grade	113	4.04	.84			
	8th Grade	187	4.11	.76			

sd: Standard Deviation, dF: Degree of Freedom

SM: Science Motivation, IM: Intrinsic Motivation, CM: Career Motivation, SD: Self-Determination, SE: Self-Efficacy, GM: Grade Motivation

* p<.05

Table 4: The descriptive statistics and t-test results of the 21st Century Skills Scale

Variable	*Gender*	*N*	*Mean*	*Standard Deviation*	*t*	*df*	*p*
21st Century Skill Level (Total)	Female	252	4.11	0.42	0.527	486.820	.598
	Male	253	4.09	0.51			
Cognitive Skills (CS)	Female	232	3.96	0.49	-0.611	462.804	.541
	Male	234	3.99	0.52			
Affective Skills (AS)	Female	240	4.36	0.46	1.930	458.295	.054
	Male	235	4.28	0.54			
Socio-Cultural Skills (SCS)	Female	236	4.02	0.52	0.052	453.571	.958
	Male	233	4.02	0.61			

According to Table 4, the results of the t-test performed on the 21st Century Skill Levels (Total) showed that the mean score of female students was *4.11 (sd= 0.42)*, while the mean score of male students was *4.09 (sd= 0.51)*. The difference between the two groups was not statistically significant, *t(486.820) = 0.527, p> .05*. Looking at the t-test results for the Cognitive Skills (CS) sub-dimension, it was observed that the mean score of female students was *3.96 (sd= 0.49)*, and the mean score of male students was *3.99 (sd= 0.52)*. The difference between the two groups was not statistically significant, *t(462.804) = -0.611, p> .05*. When the t-test results for the Affective Skills (AS) sub-dimension were analyzed, it was observed that the mean scores of female and male students were *4.36 (sd= 0.46)* and *4.28 (sd= 0.54*), respectively. The difference between the two groups was not statistically significant, *t(458.295) = 1.930, p> .05*. Considering the t-test results for the Socio-Cultural Skills (SCS) sub-dimension, it was found that the mean scores of both female and male students were *4.02* (with different standard deviation values; *sd= 0.52* and *sd=0.61*, respectively). The difference between the two groups was not statistically significant, *t(453.571) = 0.052, p> .05*.

21st Century Skill Levels of Secondary School Students According to Grade Level

In this study, the possible differences in the 21st-century skill levels, cognitive skills, affective skills, and socio-cultural skills of the students according to their grade levels were examined using One-Way ANOVA analysis. The descriptive statistics and One-Way ANOVA results of the students obtained from the 21st-century skills scale total score and its sub-dimensions are presented in Table 5.

Table 5: The Descriptive Statistics and ANOVA results of the 21st-Century Skills Scale and Its Sub-dimensions

Assessment	*Grade Level*	*N*	*Mean*	*sd*	*F*	*df1, df2*	*p*
21st C	5th Grade	114	4.25	.39	11.11	3.506	.000*
	6th Grade	83	4.24	.54			
	7th Grade	114	4.06	.47			
	8th Grade	199	3.99	.43			
CS	5th Grade	105	4.17	.43	13.77	3, 466	.000*
	6th Grade	78	4.12	.54			
	7th Grade	103	3.86	.56			
	8th Grade	184	3.86	.45			
AS	5th Grade	108	4.44	.38	5.89	3.475	.001*
	6th Grade	78	4.44	.58			
	7th Grade	110	4.29	.50			
	8th Grade	183	4.23	.50			
SCS	5th Grade	111	4.13	.53	6.03	3, 470	.000*
	6th Grade	72	4.15	.66			
	7th Grade	104	4.04	.52			
	8th Grade	187	3.89	.53			

sd: Standard Deviation, df: Degree of Freedom

21.st C: 21st-Century Skill Level, CS: Cognitive Skills, AS: Affective Skills, SCS: Sociocultural Skills

p<.05

According to Table 5, the mean 21st-century skill level scores were *4.25 (sd= .39)* for the 5th grades, *4.24 (sd= .54)* for the 6th grades, 4.06 *(sd= .47)* for the 7th grades, and *3.99 (sd= .43*) for the 8th grades. There was a significant difference between grade levels in terms of 21st century skill levels, *F (3, 506) = 11.11, p< .05*. According to the Bonferroni results, there was a significant difference between 5th grade and 7th grade and between 5th grade and 8th grade *(p< .05)*. Moreover, significant differences were found between 6th grade and 7th grade and between 6th grade and 8th grade *(p< .05)*.

When the cognitive skill (CS) level was analyzed in Table 5, the mean cognitive skill levels of 5th, 6th, 7th, and 8th grade students were *4.17 (sd= .43), 4.12 (sd= .54), 3.86 (sd= .56)*, and *3.86 (sd= .45)*, respectively. A significant difference was found between grade levels in terms of cognitive skills, *F (3.466) = 13.77, p< .05*. According to the Bonferroni results, there was a significant difference between 5th grade and 7th grade and between 5th grade and 8th grade *(p< .05)*. Moreover, significant differences were found between 6th grade and 7th grade and between 6th grade and 8th grade *(p< .05)*.

Looking at the affective skill (AS) level in Table 5, the mean affective skill levels were *4.44 (sd= .38)* for 5th grades, *4.44 (sd= .58)* for 6th grades, *4.29 (sd= .50)* for the 7th grades, and *4.23 (sd= .50)* for the 8th grades. A significant difference was found between grade levels in terms of affective skills, *F (3.475) = 5.89, p< .05*. The Bonferroni results showed that there was a significant difference only between the 5th grade and the 8th grade *(p< .05)*.

When the socio-cultural skills (SCS) level was examined in Table 5, the mean scores concerning the socio-cultural skills levels of 5th, 6th, 7th, and 8th grade students were *4.13 (sd= .53), 4.15 (sd= .66), 4.04 (sd= .52),* and *3.89 (sd= .53)*, respectively. A significant difference was determined between grade levels in terms of socio-cultural skills, *F (3.470) = 6.03, p< .05*. The Bonferroni results showed that there was a significant difference only between the 5th grade and the 8th grade *(p< .05)*.

Investigation of the Relationship Between Science Motivation and 21st-Century Skill Level

The relationship between the science motivation of the students and their 21st-century skills was examined within the scope of the study. The Pearson correlation coefficients between the science motivation of the students and their 21st-century skills are presented in Table 6.

According to Table 6, significant and positive correlations were found between science motivation and 21st-century skill levels. There is a moderate positive relationship between Science Motivation (Total) and 21st-Century Skill Level (Total) *(r= .607, p< .05)*. In addition, a moderate relationship was found between Intrinsic Motivation (IM) and 21st-Century Skill Level (Total) *(r= .438, p< .05)*. A stronger relationship was found between Self-Determination (SD) and 21st Century Skill Level (Total) *(r= .558, p< .05)*. A moderate relationship was observed between Cognitive Skills (CS) and Science Motivation Level (Total) *(r= .576, p< .05)*.

Model Fit Goodness of Measurement Models Created for Secondary School Students' Science Motivation and 21st-Century Skills

In this study, the model data fits, and factor loads of the sub-dimensions of the scales were examined using the confirmatory factor analysis (CFA) method for the Science Motivation Scale (SM) and the 21st Century Skills Scale (21st-CS). In Table 7, model data fit indices related to the CFA results of the SM and 21st-CS scales are presented.

For the SM scale, the chi-square/sd ratio is less than *5*, and the RMSEA and SRMR values are less than *0.080*. Hu and Bentler (1999) have stated that if the RMSEA value is less than *.06* and the SRMR value is less than *.08*, the model shows a good fit. In this context, the obtained RMSEA and SRMR values for the SM scale confirm that the model shows a good fit. Additionally, the NFI, CFI, and IFI values are greater than

Table 6: The Pearson Correlations Between Science Motivation and 21st Century Skill LevelszzL

	21st Century Skill Level (Total)	*Cognitive Skills (CS)*	*Affective Skills (AS)*	*Socio-Cultural Skills (SCS)*
Science Motivation Level (Total)	.607**	.576**	.567**	.507**
Intrinsic Motivation (IM)	.438**	.391**	.395**	.378**
Career Motivation (CM)	.457**	.449**	.479**	.354**
Self-Determination (SD)	.558**	.531**	.543**	.459**
Self-Efficacy (SE)	.415**	.384**	.356**	.372**
Grade Motivation (GM)	.552**	.539**	.509**	.444**

* p<.05

Table 7: Model Data Fit Indices for 21st-CS and SM Scales

Scale	*Chi-square/sd*	*RMSEA*	*SRMR*	*NFI*	*CFI*	*IFI*	*RFI*
Science Motivation (SM)	2.455	0.053	0.052	0.868	0.917	0.917	0.850
21st-Century Skills (21stCS)	1.776	0.038	0.044	0.773	0.885	0.886	0.756

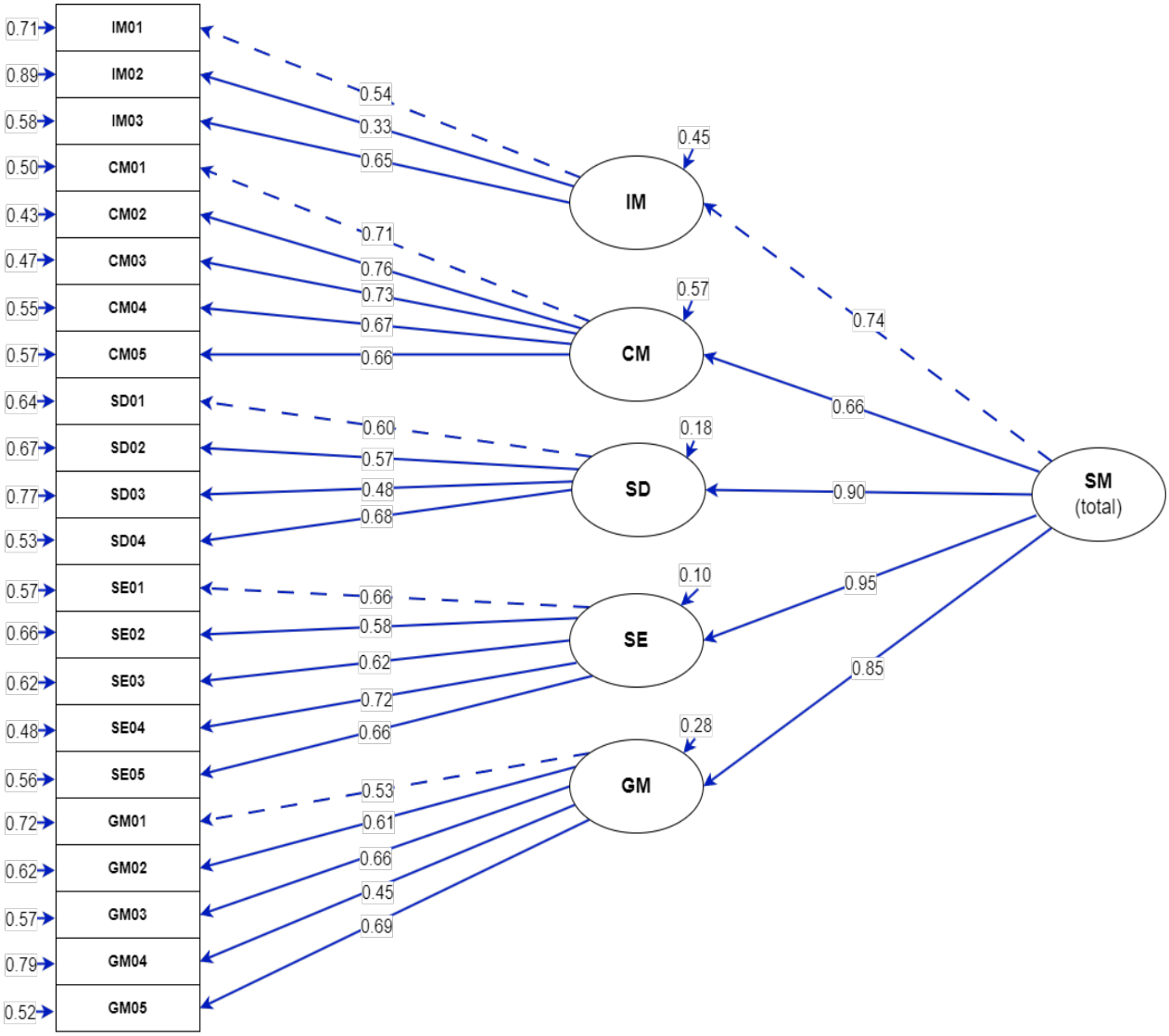

Fig. 1. The factor loads for the sub-dimensions of the SM scale

0.90, and these values being above *.90* can be interpreted as the model showing an excellent fit (Bentler, 1990; Hu & Bentler, 1999). Similarly, for the 21stCS scale, the chi-square/sd ratio is less than 5, the RMSEA and SRMR values are less than *0.080*, and the NFI, CFI, IFI, and RFI values are greater than *0.90*. Therefore, according to the criteria stated by Browne and Cudeck (1993) and Jöreskog and Sörbom (1993), it can be said that the model and the data are in perfect harmony for this scale.

The factor loads for the sub-dimensions of the SM scale are as follows at figure 1, "Intrinsic Motivation (IM)" *.331 - .649*, "Career Motivation (CM)" *.657 - .758*, "Self-Determination (SD)" *.482 - .682*, "Self-Efficacy (SE)" *.584 - .724*, "Grade Motivation (GM)" *.455 - .693*. The factor loads related to the sub-dimensions of the SM scale are above the *.30* threshold accepted in the literature (Marsh et al., 1988). This indicates that each sub-dimension represents the general factor well.

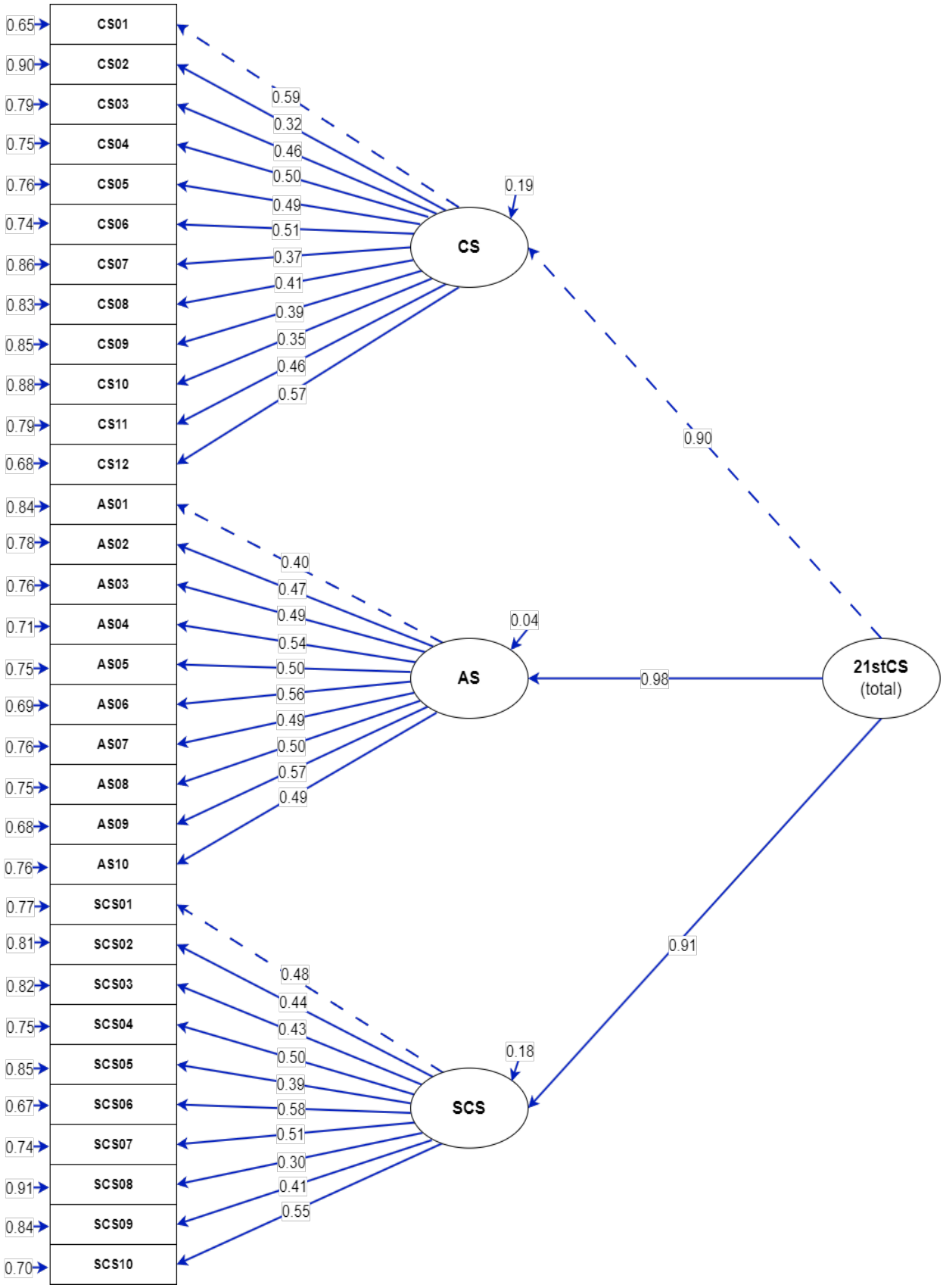

Fig. 2. : The factor loads for the sub-dimensions of the 21st-CS scale

The factor loads for the sub-dimensions of the 21stCS scale are as follows at figure 2, "Cognitive Skill (CS)" *.321 - .593*, "Affective Skill (AS)" *.398 - .566*, "Socio-Cultural Skill (SCS)" *.304 - .578*. The factor loads for the sub-dimensions of the 21st-CS scale are also above *.30*, indicating that these sub-dimensions adequately represent the general factor.

These results show that both scales have acceptable factor loads in explaining variance between their own sub-dimensions. The findings of this study indicate that both the model data fits related to the general structures of the SM and 21st-CS scales, and the factor loads related to their sub-dimensions are within acceptable limits.

Model Fit Goodness of The Structural Model in Which Secondary School Students' Science Motivation Predicts Their 21st-Century Skills

After determining the suitability for testing the measurement model and structural equation modeling, the structural model specified in Figure 3 was created for the purpose of testing the research hypothesis. The path diagram of the created model is given in Figure 3.

Figure 3, it is observed that SM has a positive effect on 21st-CS (*est. std = 0.776, p < 0.001*). This indicates that the science motivation of middle school students positively predicts 21st-century skills. In particular, there is a statistically significant relationship between science motivation and cognitive skill, affective skill, and socio-cultural skill. These findings emphasize that science education and motivation in this field may play a significant role in the development of 21st-century skills.

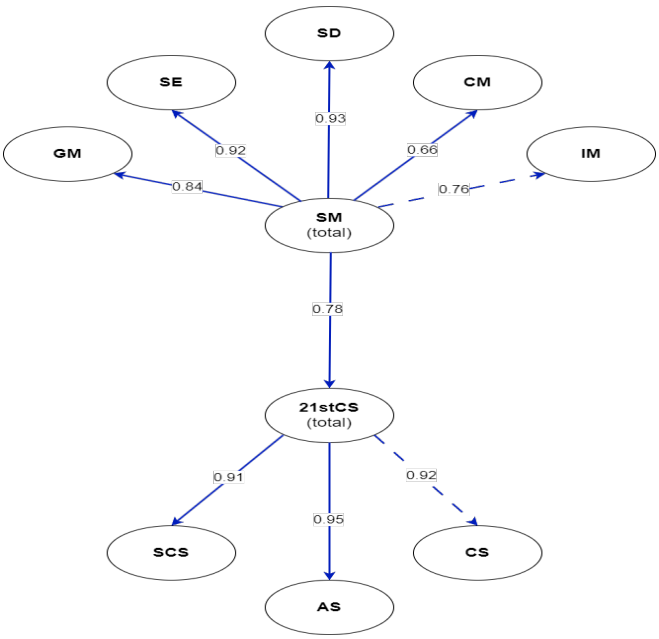

Fig. 3: Path diagram for the Structural Model in which Secondary School Students' Science Motivation Predicts 21st-Century Skills

Discussion

When the Science Motivation Scale and its subscales were examined, there was no significant difference between genders in dimensions other than Intrinsic Motivation. It is observed that the scores of male students were higher than female students in the Intrinsic Motivation dimension with a statistical significance (Table 2). In addition, a significant difference was found between the grade levels in terms of science motivation (SM) levels (Table 3). The literature contains various studies examining the gender and grade level variables of science motivation. In a study conducted with 484 secondary school students, Çeliker et al. (2015) stated that science motivation and scientific creativity were higher in female students compared to male students. They also reported that motivation decreased as the grade level increased. Yenice et al. (2012) conducted a study with 663 elementary school students, and they concluded that science motivation levels did not differ significantly according to gender variable, while they differed significantly in terms of grade level. In the study by Uzun and Keles (2010) including 531 students (6th, 7th, and 8th Grade), it was reported that science motivation was more significant among female students. On the other hand, they found that grade level did not affect science motivation. In their study conducted with 1,629 students, Yıldırım and Kansiz (2018) mentioned that science motivation differed significantly in favor of female students according to both gender and grade level. In their study on 280 7th-grade students, Demir et al. (2012) reported that science motivation had a significant difference in favor of female students in terms of gender. Gök and Doğaç (2020) conducted a study with 300 5th-grade students and found that there was no significant difference between the gender variable of 5th-grade students and the sub-factors of their science motivation. Rana et al. (2015) determined a significant difference between gender and science motivation favoring male students in their study with 800 8th-grade students. In the study conducted with 2,231 students (6th grade and 8th grade), Güvercin et al. (2010) concluded that science motivation decreased with increasing grade level and that female students had higher levels of science motivation compared to male students. In this context, when the relationship between science motivation and both grade level and gender variables is examined in the literature, it is seen that there are different results. Therefore, there are studies that support and do not support the findings of our study.

In this study, there was no significant difference between the different sub-dimensions of the 21st-Century Skills Scale according to gender; however, a significant difference was found between grade levels (Table 4, Table 5). The literature contains several studies examining 21st-century skills in terms of gender and grade level variables. In their study with 612 secondary school students, Bozkurt and Çakır (2016) reported significant differences in the level of students' possession of these skills according to grade level and gender. In addition, it was stated that the level of use of these skills by female students was higher than that of male students; however, as the grade level increased, the level of use of these skills decreased similarly in male and female students. Onur and Kozikoglu (2019) conducted a study with 920 secondary school students and found a significant difference in the level of 21st-century skills in favor of female students and in favor of 7th graders in terms of grade level. Yıldırım and Ortak (2021) reported a significant difference in favor of girls in terms of 21st-century learning and renewal skill levels in their study with 811 secondary school students; however, no significant difference was determined in terms of grade level. In this regard, no definitive conclusion has been reached in the literature regarding grade levels and gender variables in terms of 21st-century skills.

Finally, this study found positive correlations between the sub-dimensions of science motivation and the sub-dimensions of 21st-century skill levels (Table 6). Additionally, findings emphasize that science education and motivation in this field may play a significant role in the development of 21st-century skills (Table 7 and Figure 3). These results suggested that increasing students' science motivation could lead to a positive development in their 21st-century skills. The literature contains studies including different groups and some evaluations. Accordingly, Zorlu and Zorlu (2021) examined the relationship between pre-service teachers' 21st-century student and teacher skills and their beliefs about self-efficacy in science learning. As a result, they reported that pre-service teachers' 21st-century skills and their beliefs about self-efficacy predicted each other. In the study conducted by Akcay et al. (2022) with pre-service teachers, a positive and significant relationship was determined between their perceptions of efficiency in 21st-century skills and self-efficacy in mathematical literacy. The results of the study were parallel to our study conclusions in terms of the self-efficacy dimension, a sub-dimension of the science motivation scale. In 2015, Mai and colleagues investigated the relationship between motivation, participation, and achievement satisfaction in science education among middle school students in Malaysia. In this study, it was found that students' motivation significantly predicted their achievements, but students' participation or achievement satisfaction did not significantly predict their achievements. Aydın (2021) conducted a study with undergraduate and associate degree students in foreign language preparatory classes and determined that there is a moderate, positive, and significant relationship between the 21st-century skills of foreign language preparatory class students and their achievement-oriented motivation and motivation to learn English. All these results indicated how the relationship between science motivation and 21st-century skills was affected by both gender and grade level variables and to what extent they were related to each other.

Conclusion

The extensive research presented underscores the intricate relationship between science motivation, 21st-century skills, and various demographic factors such as gender and grade level. A recurring theme in these studies is the significant role of gender in influencing science motivation and 21st-century skills. While some studies indicate higher science motivation among female students, others highlight male students' dominance. Similarly, the grade level also emerges as a crucial factor, with many studies noting a decline in motivation and skill proficiency as students progress through grades. Furthermore, the interconnectedness of science motivation and 21st-century skills is evident, suggesting that fostering motivation in science can potentially enhance students' proficiency in 21st-century competencies.

Suggestion

The study can be repeated with participants from different grade levels and different regions. Only quantitative data were collected in the study. The study can be supported by qualitative data. Scales can be re-evaluated by including different demographic information. Additionally, Different scales can be used to determine the relationship between science motivation and 21st-century skills.

Limitation

The study had some limitations. The fact that the study was conducted only with secondary school students and the students in Malatya province could be considered a limitation. Only quantitative data were collected in the study. And, only gender and class level were examined in terms of demographic variables.

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