Investigation of the Relationship between the Scientific Process Skills, Self-Regulation Skills, and Academic Achievement, of Middle School Students in Science

Müzeyyen Barut[1] & Zeynep Yüce[2,*]

[1]Graduate School of Natural and Applied Sciences, Kafkas University, Kars, Türkiye

[2]Dede Korkut Faculty of Education, Kafkas University, Kars, Türkiye

*Correspondence: Department of Mathematics and Science Education, Dede Korkut Faculty of Education, Kafkas University, Kars, Türkiye. E-mail: korkmazeynep@gmail.com

Received: March 2, 2025 Accepted: March 12, 2025 Online Published: March 14, 2025

doi:10.5430/wje.v15n1p78 URL: https://doi.org/10.5430/wje.v15n1p78

Abstract

In an ever-changing world, it is impossible for individuals to acquire all existing knowledge, just as it is challenging to predict which knowledge will be necessary for the future. The critical factor here is to concretize or make raw knowledge useful. Therefore, it has become imperative to develop students' abilities to analyze and utilize knowledge that will benefit them in the future.

This study looked at the association between achievement in sciences courses and the scientific process skills and self-regulation skills of middle school students. The survey model was used in the study conducted for this purpose. The study was conducted with 6th, 7th and 8th grade students studying in a district in the southeast of Türkiye in the 2021-2022 academic year. The sample of the study consists of 428 female and 321 male students.

According to the findings obtained because of the analysis; It was determined that students' scientific process skills, self-regulation skills and science academic achievement showed a statistically significant difference according to their gender, their liking for science course and the school they attended. In addition, according to the correlation test results, moderate or weak positive correlation relationships were detected between scientific process skills, science academic achievement and self-regulation skills. At the same time, according to the findings, it was seen that all the variables were statistically significant in predicting each other. In other words, it can be said that there is a mutual causality between these variables. Because each variable plays a role in explaining the other variable.

Keywords: middle school students, scientific process skills, academic achievement, self-regulation skills, science education

1. Introduction

Rapid changes are occurring in both industry and science nowadays due to the industrial revolution, called "Industry 4.0" (Vaidya, Ambad, & Bhosle, 2018). Since the last industrial revolution, when machine power supplanted humans resources, it has become crucial for people to possess 21st century skills, generate information, and use that knowledge (Puncreobutr, 2016). The important factor here is to concretize this raw information or make it useful. In other words, individuals; they need to have knowledge, know how to access information, be able to use information in daily life, be active in this process and control their own learning. However, in a rapidly changing world, it is not possible for individuals to access all of the existing information, and it is also difficult to predict which of these information will be needed in the future (Georghiades, 2004). Additionally, continuously conveying new information to students is not feasible. Therefore, it has become mandatory to teach students how to acquire information and develop the skills necessary to examine any information (Kipnis and Hofstein, 2008). In this regard, it has become essential for students to develop appropriate learning strategies, learn how to pursue their academic goals, and organize their actions toward this purpose (Ciolacu et al., 2017). Thus, it has become necessary for students to possess self-regulation skills and scientific process skills.

In recent years, many countries have prioritized scientific thinking and scientific process skills in their curricula. According to Johnston (2009), scientific process skills are crucial for enhancing students' cognitive development and ensuring their active participation in the teaching and learning process (Papanastasiou and Zembylas, 2004). In this context, the acquisition of scientific process skills increases the retention of the learned information. The reason for this is that the student is active in learning the information and establishes connections between pieces of knowledge (Temiz and Tan, 2003). As the student shifts from a passive to an active role, the student becomes the subject of education. The student's active involvement in this learning process brings about "self-regulation". Since an educational environment or setting is not homogeneously distributed, some students may grasp the topics immediately, while others may need more attention and find it challenging to comprehend the information. In the 19th century, these differences were believed to be due to intelligence, while in the 20th century, learning differences were emphasized. This situation contributed to the emergence of the concept of self-regulation (Aydın and Demir Atalay, 2015). Zimmerman (1990) stated that self-regulation is not a mental ability. According to Zimmerman (2002), self-regulation refers to the thoughts, emotions, and behaviors that individuals develop and cyclically emerge in their pursuit of goals. Self-regulation is defined not as a mental ability or academic skill but as a self-managed process in which learners adapt their cognitive competencies to academic abilities (Zimmerman, 2002). Self-regulated individuals influence, manage, and control their own behaviors (Senemoğlu, 2011).

Self-regulated learning strategies are defined as a student's control of his/her own learning process by using metacognitive, behavioral and motivational techniques (Zimmerman, 1990; Zimmerman and Pons, 1986). According to Zimmerman (1990), students with self-regulated learning skills are aware of the information and skills they need and take the necessary steps for this. Pintrich and De Groot (1990) also stated that self-regulated learning strategies include students' metacognitive strategies and self-management. One of the fundamental aspects of self-regulated learning is students' ability to effectively select, combine and coordinate cognitive strategies (Boekaerts, 1999). In general, self-regulated learners set a goal to achieve and control their behavior, motivation, emotions and cognitions to achieve this goal (Pintrich, 1995).

In this context, in today's educational paradigm, it has become important to cultivate students who are capable of acting independently, thinking critically, taking responsibility for themselves, setting goals, determining appropriate methods to reach these goals, being active in the learning process, and having the ability to self-assess. The literature supports this, showing that students with high self-regulation skills also tend to have higher academic achievement (İsrael, 2007).

In this regard, individuals who acquire scientific process skills and self-regulation skills can be more successful in planning and controlling their learning. These skills are special abilities that facilitate learning science, motivate students, develop a sense of responsibility in their own learning, enhance the retention of learning, and teach research methods (Carey et al., 1989). According to Bredderman (1983), these skills, used to understand and improve knowledge, are applicable to all fields of science and reflect the correct behaviors of scientists when solving problems or planning an experiment. Therefore, these skills, which are considered effective in teaching and learning, hold an important place in science education.

Malnutrition, hunger, pollution, pandemics, and climate change are just a few of the many global issues that humanity is currently facing. These issues are closely related to science, and science education is essential to ensuring that students, who will be the ones making decisions in the future, have both the knowledge and the skills needed to understand and solve these issues. Under these conditions, science and technology education play a key role in the future of society. Science and technology education is highly significant in training individuals who possess scientific process skills such as observation, data collection, and inference, as well as skills such as information searching, critical thinking, problem identification, and problem-solving. Topsakal (2005) describes the science and technology course as a window that helps students acquire the necessary knowledge, skills, attitudes, and values to become conscious and responsible citizens and succeed in their future professions. In this context, a general review of the literature suggests that scientific process skills and self-regulation skills influence science education and education in other fields during the teaching and learning process. In this regard, examining the relationship between self-regulation skills, scientific process skills, and students' academic achievement levels is important.

1.1 The Aim of the Study

In the study conducted for this purpose, the relationship between the scientific process and self-regulation skills used by middle school students in science courses and their academic achievement was examined.

2. Method

2.1 Model of the Study

The survey model has been used in this study. The survey model is a research method used to collect extensive information about a particular subject, event or group. In this model, the researcher examines a large sample or data set to understand the current situation, trends, or relationships. Usually, surveys, observations, or existing data sources are used in this type of research.

2.2 Sample of the Study

The sample of the study consists of 749 students studying in the 6th, 7th and 8th grades in 19 different middle schools in a district of Şanlıurfa province in southeastern Türkiye in the 2021-2022 academic year. 428 of the students participating in the study were girls and 321 were boys. In sample selection, purposive sampling, one of the non-probability sampling methods, has been used.

2.3 Data Collection Tools

The following measurement tools were used in this study:

2.3.1 Scientific Process Skills Scale

The scientific process skills of middle school students were investigated using the "Scientific Process Skills Scale" developed by Aydoğdu et al. (2012), which consists of 27 items. The reliability coefficient (KR-20) of the 27-item scale was found to be 0.83.

2.3.2 Perceived Self-Regulation Scale

The "Perceived Self-Regulation Scale" developed by Arslan and Gelişli (2015) was used to examine the self-regulation skills of middle school students. The scale is a 5-point likert type and consists of 16 items. The internal consistency reliability coefficients for the subscale of openness were 0.84, for the subscale of search were 0.82, and for the entire scale, it was found to be 0.90 (Arslan and Gelişli, 2015).

2.3.3 Demographic Information Questionnaire

A demographic information questionnaire was prepared by the researcher in order to obtain demographic information such as the school the students attended, their grade levels, their parents' education level, and whether they liked the science course. Additionally, to determine their academic achievement levels in science, the final science grades for the 2021-2022 academic year were asked.

2.4 Data Analysis and Procedures

The data obtained from the sample group were analyzed using the SPSS 23.0 package program. First, it was investigated whether the data showed a normal distribution, and it was found that the data did not exhibit a normal distribution. Therefore, non-parametric methods, which are alternatives to parametric methods, were used in the study. Additionally, the power of the test and effect size (η2) values were also calculated.

3. Findings

3.1. Descriptive Statistics of Students Participating in the Study

Table 1 shows the demographic characteristics of the 749 students who participated in the study.

Table 1. Frequency and Percentage Distributions of Demographic Characteristics of Students Participating in the Study

	Group	**f**	**%**
Gender	Female	428	57.1 %
	Male	321	42.9 %
Mother's Educational Status	Illiterate	293	39.1 %
	Primary school	259	34.6 %
	Middle school	107	14.3 %
	High school	52	6.9 %

	Higher education	38	5.1 %
Father's Educational Status	Illiterate	89	11.9 %
	Primary school	240	32 %
	Middle school	219	29.2 %
	High school	108	14.4 %
	Higher education	93	12.4 %
Grade	6th grade	242	32.4 %
	7th grade	252	33.6 %
	8th grade	255	34 %
School	School A	41	5.5 %
	School B	44	5.9 %
	School C	67	8.9 %
	School D	53	7.1 %
	School E	29	3.9 %
	School F	72	9.6 %
	School G	25	3.3 %
	School H	10	1.3 %
	School I	58	7.7 %
	School K	31	4.1 %
	School L	72	9.6 %
	School M	40	5.3 %
	School N	37	4.9 %
	School O	28	3.7 %
	School P	15	2 %
	School R	21	2.8 %
	School S	10	1.3 %
	School T	24	3.2 %
	School U	72	9.6 %
Liking Science Course	Yes	675	90.1 %
	No	74	9.9 %

Table 2. Science Process Skills, Self-Regulation Skills and Academic Achievement Levels of Middle School Students

	N	Min.	Max.	Mean	Std. Deviation
Science Academic Achievement	749	15	100	75.3	18.87
Science Process Skills	749	2	27	13.14	5.46
Self-Regulation Skills	749	16	80	58.25	10.02

According to Table 2, the highest grade received by students in the science academic achievement is 100 and the lowest grade is 15. The average grade of the science academic achievement was found to be 75.3. According to this result, it was seen that the grade average of the science academic achievement was at a good level.

The highest scientific process skill score obtained from the research was 27, and the lowest score was 2. In this case, the average science process skill score is 13.14. In the studies conducted by Darmaji, Kurniawan and Irdianti, (2019) and Kösece (2020), students' scientific process skills were found to be medium and above. In this study, students' scientific process skills were found to be at a medium level.

The highest-grade students received from the self-regulation skills test was 80 and the lowest grade was 16. The average grade is 58.25, which is a good garde according to Yamaç (2011). In this context, it can be said that students' self-regulation skills are high.

3.2 Statistical Findings According to Different Variables

Table 3. Mann-Whitney U Test Results Regarding Gender, Liking Science Course, and Science Process Skills

	Group	N	Mean Rank	Sum of Ranks	Z	U	p	η2
Gender	Female	428	392.34	167923.5	-2.54	61270.5	0.01*	0.09
	Male	321	351.87	112951.5				
Liking Science Course	Yes	675	382.97	258504	-3.05	19596	0.00*	0.11
	No	74	302.31	22371				

*p<0.05

When Table 3 is examined; It was determined that students' scientific process skills showed a statistically significant difference according to their gender. It was determined that female students had more scientific process skills than male students (392.34>351.87). The effect size for gender (η2 = 0.09) was calculated and it was seen that the effect of gender on science process skills was quite low.

It was determined that students' scientific process skills showed a statistically significant difference depending on their liking science course. It was determined that students who liked the science course had more scientific process skills (382.97>302.31) than students who did not like the course. The effect size (η2 = 0.11) was calculated for whether you liked the science course or not, and it was seen that the effect of liking or disliking the course on science process skills was quite low.

Table 4. Kruskal Wallis-H Test Results Regarding Grade, Mother's Educational Status, Father's Educational Status, and Scientific Process Skills

	Group	N	Mean Rank	df	χ^2	p	η2	Significant Difference Between Groups	η2
Grade	6th grade	242	305.45	2	37.05	0.00*	0.04	1<2	0.19
	7th grade	252	408.01					1<3	0.19
	8th grade	255	408.38						
Mother's Educational Status	Illiterate	293	349.33	4	19.46	0.00*	0.02	1<2	0.07
	Primary school	259	385.32					1<4	0.09
	Middle school	107	353.17					1<5	0.12
	High school	52	432.29					3<4	0.07
	Higher education	38	485.70					3<5	0.12
								2<5	0.09
Father's Educational Status	Illiterate	89	311.13	4	19.52	0.00*	0.02	1<3	0.09
	Primary school	240	355.16					1<4	0.13
	Middle school	219	379.38					1<5	0.13
	High school	108	424.59					2<5	0.08
	Higher education	93	419.43					2<4	0.10

*p<0.05

When Table 4 is examined; It was determined that students' scientific process skills showed a statistically significant difference according to the grades they studied. Since there was a significant difference between the groups as a result of the Kruskal Wallis-H test, pairwise comparisons Mann Whitney-U analysis was performed to determine the groups with differences. According to the end of the Mann Whitney-U test, it was determined that the scientific process skills of 7th grade and 8th grade students were significantly higher than those of 6th grade students, and that the scientific process skills of 7th grade and 8th grade students did not differ statistically.

It was determined that students' scientific process skills showed a statistically significant difference according to their mother's education level. Since there was a significant difference between the groups because of the Kruskal Wallis-H test, pairwise comparisons Mann Whitney-U analysis was performed to determine the groups with differences. According to the end of the Mann Whitney-U test; It has been determined that the scientific process skills of students whose mothers are primary school, high school and university graduates are significantly higher than the scientific process skills of students whose mothers are illiterate, similarly, the scientific skill processes of students whose mothers are high school and university graduates are higher than the scientific process skills of students whose mothers are middle school graduates, and finally, the scientific skill processes of students whose mothers are university graduates are higher than the scientific process skills of students whose mothers are primary school graduates. No statistical difference could be detected between other groups.

It was determined that students' scientific process skills showed a statistically significant difference according to their father's educational status. Since there was a significant difference between the groups because of the Kruskal Wallis-H test, pairwise comparisons Mann Whitney-U analysis was performed to determine the groups with differences. According to the result of the Mann Whitney-U test; It has been determined that the scientific process skills of students whose mothers are primary school, high school and university graduates are significantly higher than the scientific process skills of students whose mothers are illiterate, similarly, the scientific skill processes of students whose mothers are high school and university graduates are higher than the scientific process skills of students whose mothers are middle school graduates, and finally, the scientific skill processes of students whose mothers are university graduates are higher than the scientific process skills of students whose mothers are primary school graduates. No statistical difference could be detected between other groups.

The effect size was calculated to determine how much of the total variance explained by the significant differences in Table 4. According to the findings; effect sizes of "$\eta 2 = 0.04$ for grade", "$\eta 2 = 0.02$ for mother's education level", "$\eta 2 = 0.02$ for father's education level" were determined and it was seen that the effect of these variables on scientific process skills was quite low.

Table 5. Mann-Whitney U Test Results Regarding Gender, Liking Science Course, and Self-Regulation Skills

	Group	N	Mean Rank	Sum of Ranks	Z	U	p	η2
Gender	Female	428	387.09	169954	-3.23	59240	0.00*	0.12
	Male	321	345.55	110921				
Liking Science Course	Yes	675	390.39	263514.5	-5.89	14585.5	0.00*	0.21
	No	74	264.60	17360.5				

*p<0.05

When Table 5 is examined; It was determined that students' self-regulation skills showed a statistically significant difference according to their gender. It was determined that female students had more self-regulation skills than male students (387.09>345.55). The effect size for gender ($\eta 2 = 0.12$) was calculated and it was seen that the effect of gender on self-regulation skills was low.

It was determined that the self-regulation skills of students who like science showed a statistically significant difference. It was determined that students who like science courses have more self-regulation skills (387.09>345.55) than students who do not like science courses. The effect size ($\eta 2 = 0.21$) was calculated for the science course and it was seen that the effect of liking the science course on self-regulation skills was at a normal level.

Table 6. Kruskal Wallis-H Test Results Regarding Grade, Mother's Educational Status, Father's Educational Status, and Self-Regulation Skills

	Group	**N**	**Mean Rank**	**df**	χ^2	**p**	**η2**	**Significant Difference Between Groups**
Grade	6th grade	242	384.21	2	4.71	0.09	—	—
	7th grade	252	390.08					
	8th grade	255	351.36					
Mother's Educational Status	Illiterate	293	364.18	4	1.35	0.85	—	—
	Primary school	259	385.22					
	Middle school	107	375.87					
	High school	52	379.78					
	Higher education	38	379.74					
Father's Educational Status	Illiterate	89	342.72	4	4.47	0.35	—	—
	Primary school	240	368.16					
	Middle school	219	384.53					
	High school	108	402.57					
	Higher education	93	369.07					

When Table 6 was examined, it was determined that the students' grades, mother's education level, and father's education level did not differ statistically significantly with their self-regulation skills.

Table 7. Mann-Whitney U Test Results Regarding Gender, Liking Science Course, and Academic Achievement

	Group	**N**	**Mean Rank**	**Sum of Ranks**	**Z**	**U**	**p**	**η2**
Gender	Female	428	387.43	165821.5	-2.82	63372.5	0.04*	0.10
	Male	321	358.42	115053.5				
Liking Science Course	Yes	675	427.10	254544	-3.80	53556	0.02*	0.14
	No	74	300.82	26331				

*p<0.05

When Table 7 is examined; It was determined that students' academic achievement in science courses showed a statistically significant difference according to their gender. It was determined that female students had higher academic achievement in science courses than male students (387.43>358.42). The effect size for gender (η2 = 0.10) was calculated and it was seen that the effect of gender on science process skills was low.

It was determined that the academic achievement of students who liked science courses showed a statistically significant difference. It was determined that students who like science courses have higher academic achievement in science courses (427.10>300.82) than students who do not like science courses. The effect size (η2 = 0.14) was calculated for liking the science course, and it was seen that the effect of liking the science course on the academic achievement of the science course was low.

When Table 8 is examined, it has been determined that there is no statistically significant difference in science academic achievement according to the students' grade levels.

Table 8. Kruskal Wallis-H Test Results Regarding Grade, Mother's Educational Status, Father's Educational Status, and Academic Achievement

	Group	N	Mean Rank	df	χ^2	p	η2	Significant Difference Between Groups	η2
Grade	6th grade	242	372.38	2	0.62	0.91	—	—	—
	7th grade	252	372.96						
	8th grade	255	379.50						
Mother's Educational Status	Illiterate	293	335.41	4	40.02	0.00*	0.05	1<2	0.90
	Primary school	259	382.08					1<4	0.16
								1<5	0.18
	Middle school	107	363.57					2<3	0.11
	High school	52	478.62					3<5	0.14
	Higher education	38	522.38					2<4	0.11
								2<5	0.14
Father's Educational Status	Illiterate	89	333.33	4	39.18	0.00*	0,05	1<4	0.11
	Primary school	240	336.77					1<5	0.16
	Middle school	219	362.46					2<4	0.14
								2<5	0.19
	High school	108	434.81					3<4	0.10
	Higher education	93	473.63					3<5	0.16

*p<0.05

However, a statistically significant difference was found in science academic achievement according to the educational level of the students' mothers. As a result of the Kruskal-Wallis H test, since a significant difference was found among the groups, pairwise comparisons were conducted using the Mann-Whitney U test to identify the groups with significant differences. According to the results of the Mann-Whitney U test, it was found that students whose mothers were primary school, high school, or university graduates had significantly higher science academic achievement compared to those whose mothers were illiterate. Similarly, students whose mothers were high school or university graduates had significantly higher science academic achievement compared to those whose mothers were middle school graduates. Lastly, students whose mothers were university graduates had significantly higher science academic achievement compared to those whose mothers were middle school graduates. No statistically significant differences were found among the other groups.

Furthermore, a statistically significant difference was found in science academic achievement according to the educational level of the students' fathers. As a result of the Kruskal-Wallis H test, since a significant difference was found among the groups, pairwise comparisons were conducted using the Mann-Whitney U test to identify the groups with significant differences. According to the results of the Mann-Whitney U test, it was found that students whose fathers were high school or university graduates had significantly higher science academic achievement compared to those whose fathers were illiterate, primary school graduates, or middle school graduates. No statistically significant differences were found among the other groups.

To determine how much of the total variance the significant differences in Table 8 explained, the effect size was calculated. According to the findings, an effect size of η2 = 0.05 was determined for the mother's education level and η2 = 0.05 for the father's education level, indicating that the impact of these variables on science academic achievement is quite low.

Table 9. Kruskal Wallis-H Test Results of Scientific Process Skills According to Schools

	Group	N	Mean Rank	df	χ^2	p	η2
	School A	41	369.04				
	School B	44	429.40				
	School C	67	331.75				
	School D	53	341.52				
	School E	29	475.84				
	School F	72	373.26				
	School G	25	365.96				
	School H	10	328.80				
	School I	58	266.05				
School	School K	31	321.98	18	121.59	0.00*	0.15
	School L	72	404.19				
	School M	40	410.18				
	School N	37	423.65				
	School O	28	417.04				
	School P	15	443.60				
	School R	21	375.14				
	School S	10	430.35				
	School T	24	428.35				
	School U	72	361.44				

*p<0.05

When Table 9 is examined, because of the Kruskal Wallis-H test, it was determined that scientific process skills differ statistically according to schools. To determine how much of the total variance the significant difference explained, the effect size (η2 = 0.15) was calculated. According to this finding, it was observed that the effect of schools on scientific process skills was of a small magnitude.

Table 10. Kruskal Wallis-H Test Results of Self-Regulation Skills According to Schools

	Group	N	Mean Rank	df	χ^2	p	η2
	School A	41	337.57				
	School B	44	410.35				
	School C	67	307.72				
	School D	53	387.46				
	School E	29	443.43				
	School F	72	459.21				
	School G	25	428.18				
	School H	10	314.75				
	School I	58	331.78				
School	School K	31	389.95	18	39.37	0.00*	0.05
	School L	72	203.64				
	School M	40	355.88				
	School N	37	548.93				
	School O	28	307.27				
	School P	15	503.70				
	School R	21	465.21				
	School S	10	378.80				
	School T	24	525.04				
	School U	72	349.93				

*p<0.05

When Table 10 is examined, because of the Kruskal Wallis-H test, it was determined that self-regulation skills differ statistically according to schools. To determine how much of the total variance the significant difference explained, the effect size (η2 = 0.05) was calculated. According to this finding, it was observed that the effect of schools on self-regulation skills was of a very small magnitude.

Table 11. Kruskal Wallis-H Test Results of Academic Achievement According to Schools

	Group	N	Mean Rank	df	χ^2	p	η2
	School A	41	369.04				
	School B	44	429.40				
	School C	67	331.75				
	School D	53	341.52				
	School E	29	475.84				
	School F	72	373.26				
	School G	25	365.96				
	School H	10	328.80				
	School I	58	266.05				
School	School K	31	321.98	18	139.27	0.00*	0.18
	School L	72	404.19				
	School M	40	410.18				
	School N	37	423.65				
	School O	28	417.04				
	School P	15	443.60				
	School R	21	375.14				
	School S	10	430.35				
	School T	24	428.35				
	School U	72	361.44				

*p<0.05

When Table 11 was examined, because of the Kruskal Wallis-H test, it was determined that academic achievement differ statistically according to schools. To determine how much of the total variance the significant difference explained, the effect size (η2 = 0.18) was calculated. According to this finding, it was observed that the effect of schools on science academic achievement was of a small magnitude.

Table 12. Correlation Test Results for the Relationship Between Academic Achievement, Scientific Process Skills, and Self-Regulation Skills

		Science Academic Achievement	Scientific Process Skills	Self-Regulation Skills
Science Academic Achievement	**r**	-	0.39	0.20
	p	-	0.00*	0.00*
Scientific Process Skills	**r**	0.39	-	0.21
	p	0.00*	-	0.00*
Self-Regulation Skills	**r**	0.20	0.21	-
	p	0.00*	0.00*	-

*=p<0.05

When Table 12 was examined, a moderate positive correlation was found between science academic achievement and scientific process skills, while a weak positive correlation was found between science academic achievement and self-regulation skills. Additionally, a weak positive correlation was found between scientific process skills and self-regulation skills.

Table 13. Regression Analysis Results for the Relationship Between Academic Achievement, Scientific Process Skills, and Self-Regulation Skills

	Variable	B	Std. Error B	β	t	p
Model 1	Constant	44.61	3.79	-	11.75	0.00
	Scientific Process Skills	1.26	0.12	0.37	10.76	0.00
	Self-Regulation Skills	0.24	0.02	0.10	2.75	0.00
	Dependent Variable: Academic Achievement					
	R: 0.41 R^2: 0.17	F: 76.45	p: 0.00		DW: 1.68	
Model 2	Constant	1.02	1.20	-	0.85	0.00
	Academic Achievement	0.11	0.01	0.36	10.76	0.00
	Self-Regulation Skills	0.17	0.02	0.10	3.81	0.00
	Dependent Variable: Scientific Process Skills					
	R: 0.41 R^2: 0.17	F: 76.71	p: 0.00		DW: 1.68	
Model 3	Constant	48.90	1.50	-	32.31	0.00
	Academic Achievement	0.07	0.02	0.15	3.75	0.00
	Scientific Process Skills	0.27	0.07	0.15	3.81	0.00
	Dependent Variable: Self-Regulation Skills					
	R: 0.24 R^2: 0.06	F: 23.60	p: 0.00		DW: 1.73	

In Table 13:

According to the results of Model 1, it is observed that scientific process skills and self-regulation skills can explain 17% of the dependent variable. In the ANOVA table, the F value is 76.45 and the probability value is 0.00, indicating that the established regression model is statistically significant. When the findings are examined, it is observed that for each 1-point increase in scientific process skill grades, the science academic achievement grades increases by 1.26 points, and for each 1-point increase in self-regulation skill grades, the academic grade increases by 0.24 points.

According to the results of Model 2, the explanatory power of the independent variables on the dependent variable can be understood. In the regression analysis, it is observed that scientific process skills and self-regulation skills can explain 17% of the dependent variable. In the ANOVA table, the F value is 76.71 and the probability value is 0.00, indicating that the established regression model is statistically significant. When the findings are examined, it is observed that for each 1-point increase in science academic achievement, the scientific process skill grade increases by 0.11 points, and for each 1-point increase in self-regulation skill grades, the scientific process skill grade increases by 0.17 points.

According to the results of Model 3, it is observed that scientific process skills and self-regulation skills can explain 0.06% of the dependent variable. In the ANOVA table, the F value is 76.71 and the probability value is 0.00, indicating that the established regression model is statistically significant. When the findings are examined, it is observed that for each 1-point increase in science academic achievement, the self-regulation skill grade increases by 0.07 points, and for each 1-point increase in self-regulation skill grades, the scientific process skill grade increases by 0.27 points.

4. Discussion and Conclusion

The development of digital technologies and the internet has had a significant impact not only on the lives of individuals but also on various fields, including education and commercial enterprises. In this context, those who adapt early to the continuously evolving and changing world order emerge stronger. In adapting to this evolving and changing order, scientific process skills and self-regulation skills undoubtedly play an important role. Self-regulation skills help students adapt early to the changing and transforming system, while scientific process skills aid in a clearer understanding of the system. Additionally, there are significant disparities in the wealth levels between countries today. The achievement s in the field of science in wealthier countries play a crucial role in creating these disparities. The reduction of this wealth gap between countries is influenced by advancements in the field of science. For example, more than half of the global patent applications are made by China and the USA (World Bank, 2022), showing the driving force behind the wealth of these countries. It is at this point that self-regulation skills and scientific process skills come into play. According to Marzano (1994), self-regulation involves making assessments and self-regulation is an essential learning model that must be achieved to maximize scientific process skills, and it has various indicators that need to be accomplished. Similarly, when the literature is examined, students with high self-regulation skills and scientific process skills are found to be successful in the field of science (Kitsantas, Steen and Huie, 2009; Nwafor, Obodo and Okafor, 2015; Üredi and Üredi, 2015). Based on this, the motivation for this study is to examine whether there is a relationship between scientific process skills, self-regulation skills, and academic achievement in science courses among primary school students. In this context, the sub-problems identified were investigated using statistical methods.

When the descriptive findings of the study are examined, it is found that the average science academic achievement grade is 75.30, the average scientific process skills grade is 13.14, and the average self-regulation skills grade is 58.25.

When the demographic information of the students was examined, it was determined that the educational status of the parents was remarkable, 39.1% of the mothers were illiterate and 34.6% were primary school graduates. It was determined that 11.9% of the fathers were illiterate and 32% were primary school graduates. These findings are important because analyzes show that parents' education level has an impact on student achievement.

The findings indicate that the educational level of the mother/father has a statistically significant effect on scientific process skills and science academic achievement, while there was no significant difference in self-regulation skills based on the parents' education level. The general expectation is that as the educational level of the parents increases, the student's achievement will also improve. Ural and Çınar (2014) and Aslanargun, Bozkurt and Sarıoğlu (2016) found that as the parents' education level increases, academic achievement also increases. In this context, in the study conducted, many parents are either illiterate or have only completed primary school, although a small proportion have university degrees. The findings of the study support the results of Ural and Çınar (2014) and Aslanargun, Bozkurt and Sarıoğlu (2016), as differences were identified between students with illiterate or primary school-educated parents.

According to the findings of the study related to gender, statistically significant differences were found between the students' gender and their scientific process skills, self-regulation skills, and science academic achievement. This finding supports the results of the study by Karataş et al. (2018). This situation can be attributed to various reasons. One reason might be the different responsibilities assumed by girls and boys within the family. For instance, female students tend to spend more time at home and help their mothers with household chores, whereas boys are generally freer in this regard. Another reason could be that in the Southeastern Anatolia Region, males generally receive more support in terms of education, while females are in a more disadvantaged position in this regard. The differences found between genders in this study may stem from these factors.

According to the findings, while there is a statistically significant difference in scientific process skills between the grades, no differences were found in terms of science academic achievement and self-regulation skills across the grades. This finding is consistent with the results of the study by Meriç and Karatay (2014).

According to the findings, a statistically significant difference was found between students' enjoyment of science courses and their scientific process skills, self-regulation skills, and science academic achievement. According to Balçın and Çavuş (2020), when a student enjoys a course or activity, it increases their motivation, and this motivation contributes to the student's achievement in the activity or course. In this context, this study indicates that when students enjoy science course, it boosts their motivation, which in turn differentiates their scientific process skills, self-regulation skills, and science academic achievement.

The findings also indicate that there is a difference in scientific process skills, self-regulation skills, and science academic achievement based on the schools attended by the students.

According to the results of the correlation test, a moderately strong correlation was found between scientific process skills and science academic achievement, a weak correlation between scientific process skills and self-regulation skills, and a weak correlation between self-regulation skills and science academic achievement. Furthermore, it can be stated that strengthening students' scientific process skills could enhance their achievement in science.

According to the findings, it was observed that all variables statistically significantly influence each other. That is, there is a mutual causality between these variables. This is because each variable plays a role in explaining the others. Therefore, any problem occurring in one of these variables is likely to affect the others as well. In this context, it can be stated that scientific process skills, self-regulation skills, and academic achievement in science are not substitutes for each other, but rather complementary to one another.

5. Suggestions

Each individual causes a deliberate effort to raise the caliber of human resources by undertaking education (Astiti, Ardana, and Wiarta, 2017; Made et al., 2017). Quality human resources can advance a country and ensure the sustainability of individual lives (Asrial et al., 2020). As a result, education becomes an important skill that everyone should learn.

One of the sciences learned through education is science. Moreover, science is a science that should be learned by students in the 21st century. Thinking ability is required to analyze problems that arise while studying science. In this context, self-regulation skills and scientific process skills are two important phenomena that improve the ability to analyze and think.

Based on this:

- It is essential to equip students with self-regulation and scientific process skills.
- It has been observed that students with developed scientific process skills and self-regulation skills perform better in science courses. Therefore, teachers should ensure that students actively participate in the learning process and use self-regulation skills in their course. In this regard, it is crucial to raise awareness among teachers about the importance of scientific process skills and self-regulation skills.
- To enhance students' performance in both theoretical and practical exams, science curricula should also consider self-regulation learning-based education.

References

Arslan, S., & Gelişli, Y. (2015). Algılanan öz-düzenleme ölçeği: Bir ölçek geliştirme çalışması. *Sakarya University Journal of Education*, *5*(3), 67-74.

Aslanargun, E., Bozkurt, S., & Sarıoğlu, S., (2016). Sosyo ekonomik değişkenlerin öğrencilerin akademik başarısı üzerine etkileri. *Uşak Üniversitesi Sosyal Bilimler Dergisi*, *9*(27/3), 201-234.

Asrial, A., Syahrial, S., Maison, M., Kurniawan, D. A., & Piyana, S. O. (2020). Ethnoconstructivism e-module to improve perception, interest, and motivation of students in class v elementary school. *Jurnal Pendidikan Indonesia*, *9*(1), 30-41.

Astiti, N. P., Ardana, I., & Wiarta, I. (2017). The influence of children learning in science learning model based on the culture of investigation on science knowledge competence. *Journal Of Education Technology*, *1*(7), 86-93.

Aydın, S., & Demir Atalay, T. (2015). *Öz-düzenlemeli öğrenme*. Ankara: Pegem Akademi.

Aydoğdu, B., Tatar, N., Yıldız, E., & Buldur, S. (2012). İlköğretim öğrencilerine yönelik bilimsel süreç becerileri ölçeğinin geliştirilmesi. *Journal of Theoretical Educational Science*, *5*(3), 292-311.

Balçın, M. D., & Çavuş, R. (2020). Çevre sorunlarına ilişkin proje ödevlerinin ortaokul öğrencilerinin çevre ve medya okuryazarlık düzeylerine etkisi. *e-Kafkas Journal of Educational Research*, *7*(3), 303-318.

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research*, 31(6), 445-457.

Bredderman, T. (1983). Effects of activity-based elementary science on student outcomes: A quantitative synthesis. *Review Of Educational Research*, *53*(4), 499-518.

Carey, S., Evans, R., Honda, M., Jay E., & Unger, C. (1989). An experiment is when you try it and see if it works: A study of grade 7 students' understanding of the construction of scientific knowledge. *International Journal of Science Education, 11*(special issue), 514-529.

Ciolacu, M., Tehrani, A. F., Beer, R., & Popp, H. (2017) Education 4.0-fostering student performance with machine learning methods. *IEEE 23rd International Symposium SIITME*. https://doi.org/10.1109/SIITME.2017.8259941

Darmaji, D., Kurniawan, D. A., & Irdianti, I. (2019). Physics education students' science process skills. *International Journal of Evaluation and Research in Education (IJERE), 8*(2), 293-298.

Georghiades, P. (2004). From the general to the situated: Three decades of metacognition. *International Journal of Science Education*, *26*(3), 365-383.

İsrael, E. (2007). *Özdüzenleme eğitimi, fen başarısı ve özyeterlilik*. Yayımlanmamış Doktora Tezi. Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü, İzmir.

Johnston, M. V. (2009). Plasticity in the developing brain: implications for rehabilitation. *Developmental Disabilities Research Reviews*, *15*(2), 94-101.

Karataş, F. Ö., Delen, İ., Cengiz, C., Nilgün, İ. K. T. O., & Birinci, S. (2018). Onuncu sınıf öğrencilerinin bilimsel süreç beceri düzeylerinin çeşitli değişkenler açısından incelenmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *15*(1), 468-494

Kipnis, M., & Hofstein, A. (2008). The inquiry laboratory as a source for development of metacognitive skills. *International Journal of Science and Mathematics Education*, *6*(3), 601-627.

Kitsantas, A., Steen, S., & Huie, F. (2009). The role of self-regulated strategies and goal orientation in predicting achievement of elementary school children. *International Electronic Journal of Elementary Education, 2*(1), 65-81.

Kösece, N. (2020). *Ortaöğretim öğrencilerinin günlük yaşam kimyasına ilişkin tutumları ile bilimsel süreç becerileri arasındaki ilişkinin incelenmesi*. [Yayınlanmamış yüksek lisans tezi]. Kahramanmaraş Sütçü İmam Üniversitesi.

Made, N., Lestari, D., Suniasih, N. W., & Darsana, I. W. (2017). The effect of snowball throwing learning model based on children's song on knowledge, *Competence of Pkn*, *1*, 163-168.

Marzano, R. J. (1994). Lessons from the field about outcome-based performance assessments. *Educational Leadership*, *51*(6), 44-50.

Meriç, G.., & Karatay, R. (2014). Ortaokul 7. ve 8. sınıf öğrencilerinin bilimsel süreç becerilerinin incelenmesi. *Tarih Okulu Dergisi* (TOD), *7*(18), 653-669.

Nwafor, C. E., Obodo, A. C., & Okafor, G. (2015). Effect of self regulated learning approach on junior secondary school students' achievement in basic science. *Journal of Education and Practice*, *6*(5), 45-52.

Papanastasiou, E. C., & Zembylas, M. (2004). Differential effects of science attitudes and science achievement in Australia, Cyprus, and the USA. *International Journal of Science Education*, *26*(3), 259-280.

Pintrich, P. R. (1995). Understanding self-regulated learning. N*ew Directions for Teaching and Learning*, *63*, 3-12.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33.

Puncreobutr, V. (2016). Education 4.0: New challenge of learning. *St. Theresa Journal of Humanities and Social Science, 2*(2), 92-97.

Senemoglu, N. (2011). College of education students' approaches to learning and study skills. *Egitim ve Bilim*, *36*(160), 65.

Temiz, B. K., & Tan, M. (2003). İlköğretim fen öğretiminde temel bilimsel süreç becerileri. *Eğitim ve Bilim*, *28*(127).

Topsakal, S. (2005). *Fen ve teknoloji öğretimi*. Ankara: Nobel Yayın Dağıtım.

Ural, A., & Çınar, F. N. (2014). Anne ve babanın eğitim düzeyinin öğrencinin matematik başarısına etkisi, *Eğitim Bilimleri Enstitüsü Dergisi*, *3*, 41-56

Üredi, I., & Üredi, L. (2005). İlköğretim 8. sınıf öğrencilerinin öz-düzenleme stratejileri ve motivasyonel inançlarının matematik başarısını yordama gücü. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, *1*(2), 250-260.

Vaidya, S., Ambad, P., & Bhosle, S. (2018). Industry 4.0-glimpse, *Procedia Manufacturing, 20*, 233-238. https://doi.org/10.1016/j.promfg.2018.02.034

World Bank. (2022). *World Development Report 2022*. Retrieved 01.03.2025 from https://www.wipo.int/edocs/pubdocs/en/wipo-pub-943-2023-en-wipo-ip-facts-and-figures-2023.pdf

Yamaç, A. (2011). *İlköğretim beşinci sınıf öğrencilerinin öz-düzenleyici öğrenme stratejileri ile matematiğe yönelik tutum ve başarıları arasındaki ilişkilerin incelenmesi*. Yayınlanmamış Yüksek Lisans Tezi. Afyon Kocatepe Üniversitesi, Sosyal Bilimler Enstitüsü.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*(1), 3-17.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*(2), 64-70.

Zimmerman, B. J., & Pons, M. M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, *23*(4), 614-628.

Note

This article was produced from the first author's the master's thesis titled "Investigation of the Relationship Between Secondary School Students' Scientific Process Skills, Self-Regulation Skills and Academic Achievement in Science".

Acknowledgments

Not applicable.

Authors contributions

This article is produced from a master's thesis. Müzeyyen Barut contributed as the researcher of the thesis and Assoc. Prof. Dr. Zeynep Yüce contributed as the supervisor of the thesis. The authors also contributed jointly to the preparation of this article produced from their master's thesis.

Funding

Not applicable.

Competing interests

The authors declare that there are no conflicts of interest in this article.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.