

# Determination of the Relation between Undergraduate Students' Awareness Levels Regarding Their Scientific Process Skills and Application Potentials

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**Abstract** Scientific process skills are those that facilitate learning in science, allow students to be active, improve the sense of responsibility for their own learning, increase their retention skills and also show routes and methods of research. The measurement tool used to measure undergraduate students' science process skills is a test consisting of 26 questions. This test covers identifying and checking basic skills and variables such as observation, classification, measurement, communication, and prediction using space-time relationships, and integrated process skills such as inference, operational definition, making the interpretation of data and hypotheses and conducting experiments. According to Bloom's taxonomy of cognitive development, questions also knowledge, comprehension, application, analysis, synthesis, and evaluation aspects. This study, by expediently electing among the education faculties in Turkey, was conducted with 165 undergraduate students from different departments at Faculty of Education of a big university in the Eastern Anatolia province, Turkey to determine the relationship between undergraduate students' awareness levels regarding scientific process skills and application potential, using survey method which is an implementation of non-experimental quantitative research methods. In the science process skills tests (SPST) prepared for this purpose; the effect of students' demographic characteristics (grade level, branch, academic achievement, and learning environment) on these skills were studied and results, using SPSS 18.0 software package with an analysis of variance (ANOVA), were statistically evaluated. Of these assessment results; it has been concluded that the difference in levels of awareness of the students lead to significant differences in terms of science process skills application potential, however, other variables and demographic characteristics do not lead to significant differences.

**Keywords:** *thinking, learning, scientific process skills, basic and integrated processes skills*

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## 1. Introduction

The main objective in today's information age should be students gain the skills to access information instead of passing on the available information to them, because the requirements of contemporary world make it a necessity for today's individuals to have thinking skills. Therefore, learning to think in teaching, has gained importance rather than giving and receiving information [1]. Thinking concepts and qualities have been studied since Socrates, Plato and Aristotle period and thinking has been described as reasoning, mind attribution, idea generation, reasoning, predicting, passing through the mind, remembering and imagining on a topic [2].

It is essential to know how to think in order to expand the boundaries of the mind and how to think of developing creative solutions to a problem, briefly, one needs to know

how to think. Thinking skills give us the ability to track down and edit what we learn and to control cognitive efforts. Once the individual has these skills, s/he realizes what s/he does not know and what s/he needs to know. So, this helps the individual to conduct the learning process properly [1]. Foulguie [3], regards thinking as the entirety of thinking ways. Thinking ways develop higher-order thinking skills. Using these skills, students learn how to learn, and grow up as lifelong learners. Critical thinking and creative thinking, two of the most important ones of higher level thinking skills, are described below [2,4,5,6]. In order to arrange Bloom taxonomy in a way to classify the higher-level cognitive skills that student-led curriculum wants; the taxonomy, Bloom prepared, was restated by Krathwohl et al [8]. This arrangement also targeted to provide communication between the teachers, curriculum developers and evaluators. In this new classification, held in 2001, two different aspects of

cognitive domain came to the fore. These are knowledge and scientific process. Information aspect is based on the classification associated with scientific knowledge. These are factual knowledge, conceptual knowledge, process knowledge and scientific knowledge of awareness, and refer more to the descriptive aspect of acquisitions [9,10,11,12,13]. Scientific process skills are the thinking skills that we utilize for knowledge creation, thinking on problems and the formulation of results [14]. Scientific process skills have been identified as the basic skills that facilitate learning in science, allow students to be active, develop a sense of taking responsibility for their own learning, increase the persistence of learning and also show ways and means of research [15,16,17,18,19].

Even though different researchers have made different groupings when defining skills, there is no difference in the definition of skills. Scientific process skills have a hierarchical structure, but this is not a rigid structure. For example, making observations is discussed in the basic process skills, but is also used in the most complex processes. All skills are in interaction with each other [2]. The basic and integrated process skills in science education are the key elements used in research. American Science Education Improvement Commission groups the basic process skills in the form of observation, classification, measurement, using numbers, building space-time relationship, prediction, inference and communication [2,14,20-28].

Learning of the basic process skills is a prerequisite for the development of integrated process skills. Children cannot gain integrated process skills unless they develop their basic process skills.

The integrated process skills defined by the U.S. National Science Education Standards can be classified as identifying and controlling variables, formulating a hypothesis and testing, operational definition, planning and doing experiments and interpretation of data [20].

### 1.1. The significance of the Study

Students' science process skills are one critical of the critical thinking including high-level questions. However, there are few studies in the literature regarding science process skills in the university students [1,14-23] and insufficient studies between chemistry subjects and science process skills [29,30]. We intended to examine the science process skills and application potential to the chemistry subjects of the undergraduate students attending at the different departments.

In this study, it was conducted to determine the relationship between undergraduate students' awareness levels regarding scientific process skills and their application potential.

## 2. Method

This study was applied using Survey Research Design - a non-experimental, quantitative research method-. In Survey-research model, the selected sample is studied and generalizations are made out of this sample, because the universe is a large group in a research of this kind. Since it is difficult to examine this group, a small group is formed carrying the properties of it and the research is conducted through it. As a result of this research, since the results are

statistically evaluated using the SPSS 18.0 package program, a quantitative research method is used. Here, the use of scientific process skills is evaluated in terms of both grade levels and area differences. And the influence of academic achievement and whether students have an opportunity for scientific debates with their friends in activating these processes is determined by the analysis of variance (ANOVA) and the results are explained with descriptions.

### 2.1. Subjects

The sampling consists of a total of 165 student teachers studying Chemistry Education, Mathematics Education, and Elementary Education in Turkey, a large university located in the western Anatolia, at Faculty of Education with a selection made randomly among 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> classes having 25 to 40 students. Their ages changes between 19 and 23. The subjects have been attended some science courses such as physics, chemistry, and biology in first and second classes of the departments.

### 2.2. Data Collection Tool

In this study, a 26-question scientific process skills achievement test (SPSAT), comprising thirteen scientific process skills and classified according to the information (recall) and application steps, was used taking into account Bloom's taxonomy of cognitive domain. The data instrument used contains thirteen scientific process skills including eight basic and five integrated processes in a proportion of 77% of basic and 23% of integrated ones. The basic skills are observation, classification, making measurements, using number, space-time relationship building, making predictions, inference, and communication, respectively. The questions of integrated process skills include identifying and controlling variables, formulating a hypothesis and testing, operational definition, planning and doing experiments and interpretation of data, respectively. The data includes 42% of the questions cover the application aspect while 58% of them cover the information aspect according to Bloom's taxonomy. In addition, they can be answered by participants who are attending to different departments. *Cronbach's Alpha value* of the test prepared was identified as .709.

## 3. Findings

In this section, the results obtained from 'Science Process Skills Test' were statistically analyzed in order to determine the relationship between undergraduate students' awareness levels regarding scientific process skills and their application potential.

As shown in Table 1, the highest average achievement in the questions including basic process skills and application potentials is observed on senior primary school mathematics student teachers except for integrated process skills. However, the sophomore chemistry students have obtained a high score integrated process skills. Evaluation results of within-group showed that there was a decrease in the average success of chemistry students, which they got from the questions having the basic and integrated process skills. Elementary school

senior mathematics education students had the highest average success in the questions -based on Bloom's taxonomy- that measured the awareness (knowledge) level and the potential of application. This situation is attributed to a relationship between mathematics skills and science

process skills. After that, it was observed in the table that the students with high averages in the questions measuring awareness level had an approximate average success in the questions measuring application potential.

**Table 1. Descriptive statistics results**

	Groups	N	Mean	Std. Dev.
Basic Process Skills	Sophomore students in Chemistry Education (1)	11	66.99	12.695
	Junior Students in Chemistry Education (2)	20	66.84	11.340
	Senior Students in Chemistry Education (3)	19	68.14	9.997
	Senior Students in Mathematics Education (4)	40	74.21	9.061
	Junior Students in Elementary Education (5)	75	69.54	12.061
	Total	165	70.02	11.292
Integrated Process Skills	Sophomore students in Chemistry Education (1)	11	68.83	10.725
	Junior Students in Chemistry Education (2)	20	62.14	13.333
	Senior Students in Chemistry Education (3)	19	59.40	17.342
	Senior Students in Mathematics Education (4)	40	67.86	14.008
	Junior Students in Elementary Education (5)	75	63.43	16.647
	Total	165	64.24	15.507
Awareness Level	Sophomore students in Chemistry Education (1)	11	62.42	11.652
	Junior Students in Chemistry Education (2)	20	65.67	12.477
	Senior Students in Chemistry Education (3)	19	63.86	12.032
	Senior Students in Mathematics Education (4)	40	71.67	10.099
	Junior Students in Elementary Education (5)	75	65.24	12.120
	Total	165	66.51	11.916
Application Potential	Sophomore students in Chemistry Education (1)	11	74.38	15.650
	Junior Students in Chemistry Education (2)	20	65.45	16.316
	Senior Students in Chemistry Education (3)	19	68.42	14.649
	Senior Students in Mathematics Education (4)	40	73.64	14.233
	Junior Students in Elementary Education (5)	75	71.52	13.887
	Total	165	71.13	14.547

As seen in Table 2, a significant difference ( $p < 0.05$ ) is observed among the groups in terms of awareness levels intended for scientific process skills in students. A significant difference is not observed in terms of basic process skills, integrated process skills and potential applications. According to Table 2, which expresses where the differentiation between groups take place, -in terms of the awareness levels intended for the science process skills observed in this table- the differentiation is revealed by the p value being 0.0021 ( $p < 0.05$ ) between sophomore chemistry student teachers and senior primary school mathematics student teachers. Furthermore, another differentiation is determined with p value being 0.017 ( $p < 0.05$ ) between senior chemistry student teachers

and senior primary school mathematics student teachers; the differentiation determined according to the differentiation levels between junior elementary student teachers and senior primary school mathematics student teachers is observed with p value being 0.006 ( $p < 0.05$ ) (see Table 2).

As shown in Table 3, the awareness levels of students regarding scientific process skills lead to a significant difference in the utilization and application of these processes between the groups. While the significant difference value (p) between the level of awareness and application potential is 0.017, the significant difference value (p) between the level of awareness and the basic and integrated process (p) is found to be 0.000.

**Table 2. ANOVA and LSD results**

		Sum of Squares	df	Mean Square	F	p	LSD results
Basic Process Skills	Between groups	1089.547	4	272.387	2.199	.071	
	Within groups	19820.384	160	123.877			
	Total	20909.930	164				
Integrated Process Skills	Between groups	1337.919	4	334.480	1.405	.235	
	Within groups	38100.547	160	238.128			
	Total	39438.466	164				
Awareness Level	Between groups	1515.081	4	378.770	2.784	.029*	4-1 (-9.242, $p < 0.021$ ) 3-4 (7.807; $p < 0.017$ ) 4-5 (6.422; $p < 0.006$ )
	Within groups	21769.498	160	136.059			
	Total	23284.579	164				
Application Potential	Between groups	1162.244	4	290.561	1.386	.241	
	Within groups	33540.485	160	209.628			
	Total	34702.730	164				

\* $p < 0.05$

**Table 3. ANOVA results for usage of awareness levels, application potentials, basic and integrated process related to the Students' Science Process Skills**

Awareness Level		Sum of Squares	df	Mean Square	F	p
Application Potential	Between groups	4745.440	11	431.404	2.203	<b>.017*</b>
	Within groups	29957.290	153	195.799		
	Total	34702.730	164			
Basic Process Skills	Between groups	10210.677	11	928.243	13.274	<b>.000*</b>
	Within groups	10699.253	153	69.930		
	Total	20909.930	164			
Integrated Process Skills	Between groups	7880.581	11	716.416	3.473	<b>.000*</b>
	Within groups	31557.885	153	206.261		
	Total	39438.466	164			

\*p&lt;0.05

**Table 4. The results of correlation analysis between Science Process Skills and Awareness Levels**

		Awareness Level	Application Potential
Awareness Level	Pearson Correlation	1	.041
	Sig. (2-Tailed)		.600
	N	165	165
Application Potential	Pearson Correlation	.041	1
	Sig. (2-Tailed)	.600	
	N	165	165

**Table 5. The results of correlation analysis between Basic Process Skills and Integrated Process Skills**

		Basic Process Skills	Integrated Process Skills
Basic Process Skills	Pearson Correlation	1	<b>.045</b>
	Sig. (2-Tailed)		.567
	N	165	165
Integrated Process Skills	Pearson Correlation	<b>.045</b>	1
	Sig. (2-Tailed)	.567	
	N	165	165

In the [Table 4](#), the correlation coefficient between the level of awareness and the application potential is 0.041. The correlation coefficient is a parameter with values between -1 and +1. If the coefficient is positive, it states that there is a relation a positive direction.

The correlation coefficient, in the [Table 5](#), between the basic process skills and the integrated process skills is 0.045. Correlation coefficient is a parameter with values between -1 and +1.

If the coefficient is positive, it states that there is a relation in a positive direction.

As seen in [Table 6](#), it is observed that the students with higher academic achievement (Average score: 3.5-4,0) have the highest average achievement in the questions including the basic and integrated process skills and in those, evaluated based on Bloom's taxonomy, measuring the level of awareness (knowledge) and the application potential.

**Table 6. Descriptive analysis for Students' average scores and Science process skills**

		N	Mean	Std. Deviation	Std. Error
Basic Process Skills	2-2.5	41	68.68	9.485	1.481
	2.5-3	52	68.93	13.640	1.891
	3-3.5	26	68.42	11.040	2.165
	3.5-4	5	69.47	11.410	5.103
	Total	124	68.76	11.639	1.045
Integrated Process Skills	2-2.5	41	62.37	16.523	2.581
	2.5-3	52	60.71	14.110	1.957
	3-3.5	26	64.29	16.288	3.194
	3.5-4	5	80.00	7.825	3.499
	Total	124	62.79	15.545	1.396
Awareness Level	2-2.5	41	64.23	10.409	1.626
	2.5-3	52	63.72	13.295	1.844
	3-3.5	26	65.90	12.122	2.377
	3.5-4	5	73.33	6.667	2.981
	Total	124	64.73	11.985	1.076
Application Potential	2-2.5	41	70.73	15.146	2.365
	2.5-3	52	70.80	15.311	2.123
	3-3.5	26	69.23	12.876	2.525
	3.5-4	5	70.91	14.938	6.680
	Total	124	70.45	14.600	1.311

As seen in Table 7, it is observed that the academic achievement of undergraduate students does not important difference statistically ( $p>0.05$ ), among the groups, in the

basic and integrated processes of students, in their awareness levels and application potential regarding scientific process skills.

**Table 7. ANOVA results for usage of awareness levels, application potentials, basic and integrated processes related to the Students' Science Process Skills for Students' average scores**

		Sum of Squares	df	Mean Square	F	p
Basic Process Skills	Between Groups	7.263	3	2.421	.017	.997
	Within Groups	16654.340	120	138.786		
	Total	16661.603	123			
Integrated Process Skills	Between Groups	1770.388	3	590.129	2.534	.060
	Within Groups	27951.468	120	232.929		
	Total	29721.856	123			
Awareness Level	Between Groups	469.130	3	156.377	1.091	.356
	Within Groups	17199.687	120	143.331		
	Total	17668.817	123			
Application Potential	Between Groups	49.478	3	16.493	.076	.973
	Within Groups	26169.530	120	218.079		
	Total	26219.008	123			

As can be seen in Table 8, it is observed that the students in a working environment with their friends in terms of basic process skills and awareness levels, have the highest average achievement in the questions including the basic and integrated process skills and in those, evaluated based on Bloom's taxonomy, measuring

the level of awareness (knowledge) and the application potential. On the other hand, in terms of integrated skills and application potentials, the students with no working environment with their friends have higher average achievement.

**Table 8. Descriptive analysis of Students' Science Process Skills for the presence of learning environment with their friends**

		N	Mean	Std. Deviation	Std. Error
Basic Process Skills	Yes	95	68.75	12.134	1.245
	No	30	68.42	10.062	1.837
	Total	125	68.67	11.632	1.040
Integrated Process Skills	Yes	95	62.56	15.757	1.617
	No	30	64.76	16.238	2.965
	Total	125	63.09	15.836	1.416
Awareness Level	Yes	95	65.12	12.318	1.264
	No	30	64.00	11.155	2.037
	Total	125	64.85	12.015	1.075
Application Potential	Yes	95	69.76	15.318	1.572
	No	30	72.12	12.158	2.220
	Total	125	70.33	14.611	1.307

As can be seen in Table 9, it is observed that the study (debate) environments of students does not cause a significant difference ( $p>0.05$ ) in the basic and integrated

process of students and in the level of awareness and application potential regarding scientific process skills between the groups.

**Table 9. ANOVA results for usage of awareness levels, application potentials, basic and integrated processes related to the Students' Science Process Skills for learning environment**

		Sum of Squares	df	Mean Square	F	p
Basic Process Skills	Between Groups	2.519	1	2.519	.018	.892
	Within Groups	16776.206	123	136.392		
	Total	16778.726	124			
Integrated Process Skills	Between Groups	110.906	1	110.906	.440	.508
	Within Groups	30984.604	123	251.907		
	Total	31095.510	124			
Awareness Level	Between Groups	28.744	1	28.744	.198	.657
	Within Groups	17871.345	123	145.295		
	Total	17900.089	124			
Application Potential	Between Groups	127.035	1	127.035	.593	.443
	Within Groups	26343.048	123	214.171		
	Total	26470.083	124			

### 4. Results and Discussions

In this study, it was examined whether the differences in the field of undergraduate students caused a significant

difference in terms of their awareness and application potential depending on scientific processes. The realization, in terms of the awareness levels of students, of the significant difference regarding filed differences was determined with p value of 0.029 (Table 1) judging from



the findings obtained. In addition to this, looking at the average achievement scores, the students in primary school mathematics teaching department (Table 1) were found to have the highest average achievements.

In addition, a significant difference regarding the grade and age difference occurred in terms of awareness levels in students, and this difference was determined from the findings obtained by p value between chemistry teaching 2<sup>nd</sup> graders and primary school mathematics teaching 4<sup>th</sup> graders being 0.021 ( $p < 0.05$ ). Furthermore, another differentiation was determined with p value being 0.017 ( $p < 0.05$ ) between chemistry teaching 4<sup>th</sup> graders and primary school mathematics teaching 4<sup>th</sup> graders; the differentiation determined according to the differentiation levels between classroom teaching 3<sup>rd</sup> graders and primary school mathematics teaching 4<sup>th</sup> graders was observed with p value being 0.006 ( $p < 0.05$ ) (Table 2). The reason for this difference may stem from the fact that classroom teaching 4 graders and primary school mathematics teaching 3<sup>rd</sup> graders have received instruction for Science and Technology and know science process skills in the scope of this course. Similarly, as the results of the studies of [31] and [32]; it is stated that they have reached the conclusion that there is a significant difference between the grade levels of students and scientific process skills.

The academic achievements of undergraduate students caused a significant difference in terms of their awareness and application potential - depending on scientific processes-. It was detected from the findings obtained that there was not a significant difference ( $p < 0.05$ ) on student-teachers' average scores in basic and integrated processes, in their awareness levels and application potentials concerning scientific process skills, and between groups. Additionally, considering the average scores, students with high academic achievement were determined to have the highest average score.

Undergraduate students' learning environment caused a significant difference in terms of their awareness and application potential depending on scientific processes. It was detected from the findings obtained that the difference in study (discussion) environment did not cause a significant difference ( $p < 0.05$ ) in students' academic achievements, basic and integrated processes, their awareness levels and application potentials -among groups- concerning scientific process skills. Additionally, considering the average achievement scores, the students with a study environment with their friends had the highest average achievement in terms of basic process skills and awareness levels; on the other hand the students with no study environment with their friends (Table 9) had the highest average achievement in terms of integrated processes and application potentials.

There was a significant difference between undergraduate students' awareness levels regarding their scientific process skills and their application potentials. From the findings obtained, the correlation coefficient between awareness level and application potential was found to be 0.041. This value states that there is not a significant difference between the awareness levels of students and their application potentials. In addition to this, considering the average achievement scores, a student with a good level of awareness had also a good average achievement level in his/her application potential.

It was researched whether there was a significant difference between undergraduate students' basic process skills from scientific process skills and their integrated process skills. From the findings obtained, the correlation coefficient between the basic process skills and the integrated process skills was found to be 0.045. This value states that there is not a significant relation between the basic process skills of students and their integrated process skills. The cause of this condition in the students may be the fact that the examination system, which has consisted of definitions, memorization and rules, and has promoted solving verbal and numerical problems speedily without understanding rather than expanding meaningful learning potentials, has been widely and effectively in the force since the early years of their elementary education. As a result of such a systematic elimination and identification; the system cannot create students who produce things and critically approaches them by asking questions such as why, how etc. before accepting them and believe that science can provide them higher standards of life emerge. Instead, it creates those who are contented with definitions without understanding and who do this just for the sake of learning. However, questions in Education and Training is a way to develop thinking and the true sense of learning, which is based on the solutions of real and multi-dimensional problems, can only be mentioned where thinking exists. In this respect, the students must acquire the habit of doing the analysis of each question in the process of examination in terms of what each one expects from them. Individuals who can think scientifically and can actively utilize their scientific process can only be raised in this regard.

## 5. Implications

In this study, students' scientific process skills were surveyed considering the areas that students studied, grade levels, and a number of demographic characteristics. However, there may be other variables affecting the scientific process skills. So, new studies can be conducted to examine what these variables might be and how they affect the process skills.

1. A large task is to be taken on by teachers to improve students' scientific process skills. So, this type of teacher training institutions of higher education should graduate their teacher candidates in a fully equipped way.
2. Administrators and teaching staff can organize activities that can help to develop scientific process skills of students and use effective materials.
3. Today's information society needs individuals who look critically at what has been produced -instead of accepting it rapidly- with questions such as why, how etc., and can apply this knowledge to their lives valuing science; instead of those who state the definitions and the rules they memorize. In this context, teachers should pay attention to the questions asked in the exams in terms of the levels of cognitive and knowledge domains.
4. They should ask students top-level questions far from memorization, provoking creative (designer) thinking, providing a critical perspective to life, and containing situations from daily life. To be brief, exam questions

and the teaching of the lesson should be parallel with each other and should show a homogeneous distribution as much as possible.

5. Thus, students will develop high-level skills, love science and technology, and so the quality of teaching will increase. To achieve this, the restructured Bloom's taxonomy should be taught to teacher candidates, the importance of it regarding comprehension should be highlighted and the students should raise their awareness for questions asked considering this taxonomy.

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