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THE EFFECT OF TWO APPROACHES TO DEVELOPING REASONING SKILLS OF PRESERVICE SCIENCE TEACHERS

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Abstract
The aim of this study is to determine the effect of the Prediction Observation Explanation (POE) Method and the Cognitive Acceleration through Science Education (CASE) Project based activities on reasoning skills of preservice science teachers. A pretest-posttest quasi-experimental research, without a control group, design was used. The study group consisted of 93 students studying in their 2nd year of a Science Education program in the fall semester (2014-2015) at Gazi University. A "Scientific Reasoning Skills Test" (SRST) was implemented as the pretest to determine pre-scientific reasoning skills. Then, the students in the two classes were randomly divided into four groups and two of them were selected as the Implementation Group 1 (IG_1)(n_1 = 47)tocomplete 12 POE Method based activities. The other two groups labelled Implementation Group 2 (IG_2), (n2= 46) completed 12 activities developed for the CASE Project. SRST was implemented to all groups as the posttest. A statistically significant difference was observed in the scientific reasoning skills as a result of different activities that the IG_1 and IG_2 groups completed. It was seen that POE Method based activities were more effective than CASE Project based activities in developing scientific reasoning skills. In addition, scientific reasoning skills of males were more developed than females.

Keywords: Cognitive acceleration through science education, prediction observation explanation method, scientific reasoning.

INTRODUCTION

Today, with rapid developments and changes in science and technology, the knowledge and skills gained by individuals need to be one of the most important goals. Regardless of individual differences, it is necessary to help students have the skillsto approach events with an inquiring and searching mind at an early age. Scientific teaching needs to emphasize research and inquiry, critical thinking, having a sense of wonder about the world in which we live in and about our environment, identifying problems, the ability to propose solutions to problems andalso the ability to solve such problems In addition, the need for individuals who have improved decision-making and lifelong learning skills is clearly expressed (Ministry of National Education of Turkey National Board of Education, 2012). It has been claimedthat these skills can be developed within students using a teaching approach that enables mentally, physically and sensorially effective participation of students (Ozer, 2009). Moreover; ithas been seen that individuals with scientific reasoning and thinking skills can be more successful in achieving their goals and coping with difficulties (Yuksel, 2015).

To solve problems met in their daily life, individuals should possess reasoning skills which can enable the ability to seek the information they need and provide them with new information through deduction (MONE, 2000). There is a need for qualified individuals in changing life situations to be able to make suitable observations, detect problems, pose a query, test the hypothesis, generate alternative hypotheses, make appropriate decisions, generate new ideas and solve problems. This is expected to refer to individuals who have developed reasoning and thinking skills. In practice, it is not possible to face individuals with all problem situations they may encounter. But from now on, individuals who not only acquire knowledge but also can reason by making use of acquired knowledge and solve the problems by using scientific methods are able to be successful in a rapidly developing and changing world (Coban, 2010).

Many theories are put forward trying to explain how individuals may have knowledge, skill and sensorial structure, which are mentioned above, or how learning can occurs and the putting forward of new ones can continue. Some of the theories, which mostly affect education in its general meaning and science education in particular, are those put forward by Jean Piaget, Jerome Bruner, Robert Gagne and David Ausubel (Ozmen, 2004). The studies by Piaget in the field of cognitive development have a profound impact on the education system in many countries and continues to impress. According to Piaget, knowledge is not passively received by individuals. Knowledge is configured actively in the mind after the individual's own experiences and interaction with the social environment and processes of testing hypotheses mentally or making logical reasoning. Piaget, arguing that the child's cognitive development takes place by biological maturation (growth), and is shown through evaluating individuals' cognitive development in four stages, claims that each individual lives through these processes (stages) at similar ages (Ozmen, 2004).

Criticisms related to Piaget's theory of cognitive development are classification of the stages regarded as intellectual development are made based on the age and context dependence of the items available in the assessment instrument used to measure reasoning skills seirously affecting the level of success (Yazgan, Bilgin and Kılıc, 2015).

Responding to these criticisms, Lawson et al. (2000) carefully reviewed the formal operational stage again, based on individuals' mental abilities possessed at this stage (Lawson, Clark, Cramer-Meldrum, Falconer, Sequist and Kwon, 2000; Lawson, 2004). Lawson et al. (2000), divided the formal operational stage into four subgroups and reinterpreted this stage according to the mental skills and hypothesis testing skills which individuals should have.

Lawson et al. (2000) argued that the most prominent and remarkable difference among individuals at the formal operational stage was the type using the logical inference process in the form of "if.....and.....then.....therefore" or the process of hypothesis testing in different situations. According to the new classification, individuals could be grouped as; Level 0: who could not test the hypothesis even on observable events, Low Level 1: who could test the hypothesis on observable events in some cases, but not in others, High Level 1: who could test the hypothesis on observable events in a consistent manner, and Level 2: who could test the hypothesis even on unobservable events. To take into account the hypothesis testing skills in the new grouping, Lawson et al. modified the logical thinking test. Based on the modified test scores, individuals were divided into four categories that reflected their ability to test the alternative hypothesis.

Today, it is well known that knowledge is constructed in the mind of individuals depending on preliminary information, cognitive skills, environmental and cultural factors, and efficiency of student-centered education. Therefore, to determine whether the students have reasoning and hypothesis testing skills they should have, at the formal operational stage in science education, one of the preconditions for an efficient education (Lawson, 1985). It is stated that the interruptions in the development of cognitive skills at formal and concrete operational stages and the inadequacy of reasoning skills of students make giving scientific meanings to the concepts, problem solving and understanding the nature of science difficult (Lawson, 2004). Determining the level of reasoning skills anticipated at the during formal operational stage and at what efficiency they are used is important for cognitive development and concept teaching (Ates, 2002). In addition, many studies conducted in Turkey show that middle school, high school and university students' scientific reasoning and hypothesis testing skill levels are inadaquate (Ates, 2002; Ozcan and Oluk, 2007; Demirbas and Ertugrul, 2012).

In previous studies, it is reported that the inadequacy of reasoning skills at the formal operational stage may be one of the reasons for student failure in science and mathematics (Lawson, 1985). It has been shown that British students who completed the activities developed for the Cognitive Acceleration through Science Education (CASE) project during one year develop scientific reasoning skills, in addition to this their science, maths, foreign language and social sciences course successes increasing (Adey and Shayer, 1994). As seen in the result of this research, knowledge and skills that are expected to be at concrete and formal operational stages may be improved with appropriate methods and have a positive effect on success in many courses. However, the CASE Project based activities do not include the alternative hypothesis generation and testing skills of formal operational stage, redefiened by Lawson et al. (2000) and some of reasoning skills required instructional methods developed based on conceptual change approaches to learn them. In this study, it is aimed to develop scientific reasoning skills of students including hypothesis generation and testing skills with the help of Prediction Observation Explanation (POE) Method based activities.

This research sets out to;
i) identify pre-scientific reasoning skills of the students who undertook POE Method and CASE Project based activities.
ii) compare the pre-scientific reasoning skills in terms of gender.
iii) compare IG_1 and IG_2 groups according to scientific reasoning skills posttest mean scores.
iv) compare pre and post scientific reasoning skills of students who completed POE Method and CASE Project based activities.
v) compare post scientific reasoning skills of female and male students who completed POE Method and CASE Project based activities according to the mean scores.
vi) determine a possible teaching method-gender interaction in terms of post scientific reasoning skills of groups.

METHOD

This study is conducted using a pretest-posttest, quasi-experimental design without a control group. The difference between this design and pretest-posttest experimental design with a control group is that groups aren't fully formed randomly and there is no control group in this design. A symbolic view of the research design is presented in Table 1.

Table 1: Symbolic View of the Research Design

Groups	Pretest	Implementation	Posttest
IG_1	O_1	X_1	O_2
IG_2	O_3	X_2	O_4

IG_1:POE Group, **IG_2:**CASE Group, **X_1:** POE Based Activities, **X_2:**CASE Based Activities,**O_1, O_3:** Pretest Points, **O_2, O_4:** Posttest Points

Study Group

The sample of the study was selected from students who were studying in a Science Education Program with the idea of contributing to professional development of preservice science teachers at the Gazi University Gazi Faculty of Education. For this study; students studying in two classes in the fall semester of the 2014-2015 academic year were divided into two groups so that there are two groups per class. One of the groups in each class was randomly assigned to the IG_1 and the other one to the IG_2. The distribution of students in IG_1 and IG_2 groups according to gender is shown in Table 2.

Table 2: The Distribution of Students in IG_1 and IG_2 Groups According to Gender

Groups	Female		Male		Total	
	f	%	f	%	f	%
IG_1	40	43	7	7.5	47	50.5
IG_2	40	43	6	6.5	46	49.5

As seen in Table 2, the number of students in IG_1 group is 47 (40 female and 7 male), the number of students in IG_2 group is 46 (40 female and 6 male). Based on this data, it is possible to say that the number of students in IG_1 and IG_2 groups and their distribution according to gender is equivalent. However, the number of males is far less than females. This situation can be a disadvantage of studying with present groups and a limitation of the research.

Procedure

First, the pilot implementation of materials developed for this study was held with different students who participated in this research. In the pilot implementation; POE Method based activities were implemented in a group consisting of 25 students and CASE Project based activities were implemented in the other group consisting of 27 students. A pilot implementation was first undertaken. The aim of the pilot study was to identify problems encountered during the implementation of the developed and adapted activities and to avoid encountering similar problems in actual implementation by taking the necessary precautions.

Second, the actual implementation of the research was held with the 93 students who were studying in the fall semester of 2014-2015 academic year. The Scientific Reasoning Skills Test (SRST) was implemented as a pretest in both groups.

In the research, variables such as ambient conditions of implementation classes, the equal number of activities to develop the same reasoning skills and lesson time, etc. were made to be the same for IG_1 and IG_2 before the experimental procedure. Students of IG_1 group were taught with activities developed. POE Method based using worksheets two hours per week for 12 weeks during a semester. With regard to of students IG_2 group, they were taught with CASE Project based activities adapted to Turkish two hours per week for 12 weeks during a semester.

Taking into consideration the subdimensions of scientific reasoning skills, a lesson plan including POE Method and CASE Project based activities was prepared two hours per week for 12 weeks. Instructions for weekly lessons both in IG_1 and IG_2 groups were set forth in detail in these plans. In this way, the subject of 12 weekly lesson for IG_1 and IG_2 groups was determined with 12 weekly lesson plans.

Students in IG_1 group was trained to reason via the POE method other than in the time allocated for the activities. They were provided information for implementation of the methods and the lower steps. A similar application was made to students in IG_2 group with CASE Project based activities. The necessary information on CASE Project based activities was given to them.

Implementation lasted for 12 weeks. In the activities, both IG_1 group and IG_2 group students studied in groups of 4-5 people. Finally SRST was implemented as the posttest in both groups. Students in both groups were also asked for feedback about the subject of the lesson for two hours each week.

Development of POE Activities

The ability to gain knowledge and skills about science effectively to students is directly related to the quality of conceptual teaching to be applied in science courses (Ates and Bahar, 2002).This method which is used to reveal knowledge of students about a particular subject and to provide them with a conceptual change in teachinghas been developed by White and Gunstone (1992). It is referred to in the literature as POE (Prediction-Observation-Explanation) Method.

With the POE Method, students are faced with real problem situations rather than theoretical problems. Thanks to this, students are actively involved in the solution of the problem situation (White and Gunstone, 1992, p. 56). POE-based learning allows students to use scientific process skills and allows them to work as scientists using scientific methods. This learning approach is very suitable for science lessons, which enables students to relate new knowledge to previous knowledge and to construct and express their knowledge in a meaningful way. It permits students to take responsibility when they work on their own or as a group, to express themselves and to develop their self-confidence. In addition, this method helps learners develop positive attitudes toward science courses because they are constantly active, responsible for their own learning, and able to apply what they learn in everyday life (Bilen, 2009).

In total, 12 POE based activities were prepared and used in this research to improve scientific reasoning skills of students. One such activity is shown in Annex 1. The first step in the activity worksheets were used for the prediction process. For this, pictures to attract students' attention were given and students were asked through an open-ended question to explain their predictions about the events in the activities with their reasons.

This approach was used because CASE Project based activities does not include the alternative hypothesis generation and testing skills of formal operational stage reviewed by Lawson et al. (2000). According to research it was seen that misunderstanding in the minds of the students affect their predictions about the events (Liew and Treagust, 1998). Thanks to prediction process by looking at their predictions students' misconceptions and ways of thinking are identified in detail. In summary, prior knowledge of the students is provided and their curiosity is increased in prediction process. Prediction process is the one at which students desire to know and learn and at this process it is expected to gain research and inquiry skills by reasoning.

Observation, the second process, aims at the development of students' reasoning skills by gaining critical thinking, identifying problems and solving skills. In this process, implementations in which students are expected to develop their scientific reasoning skills by making observations about pictures and questions are given. In each POE activities, there was an activity in the observation process for students to understand the answers of questions asked in the prediction process better. Care was taken for the event in the activities to be easily observed by the students and to make contradictions in their minds (White and Gunstone, 1992). With these contradictions, detailed information about students' understanding was reached. Activity guidelines were expressed to the students in the form of instructions step by step. The way to do the activity was shown with pictures or shapes.

In the third and final process that is the process of explanation students were enabled to use the reasoning skills by the development of their decision-making skills. In this process students were asked to make explanations in order to eliminate the contradictions that occur between their predictions and observations, in other words, to reach a conclusion in line with the activities carried out and answers of the questions and to express this result. According to the intensity of topics, sometimes more than one relevant activity were given.

Adaptation Process of CASE Based Activities

CASE, based largely on the work of Piaget and Vygotsky, is a teaching approach which arose from the research about cognitive development. It aims to develop children's thinking ability by enhancing them with higher-order thinking skills that are called "formal operations" by Piaget. It makes this by developing children's science understanding which may sometimes be difficult for most of them. CASE Project is a project carried out in the United Kingdom between the years 1984-1987 on selected samples representing a large portion of the school population of a country. CASE, which is now widely used in schools of the United Kingdom and is experimented in different countries, is an intervention program in the existing curriculum and it is originally for children between the ages of 11 and 14. A course curriculum consisting of various activities in order to develop scientific reasoning skills of the students are applied to the students (Adey, 1999).

The following steps were taken for the adoption of CASE Project based activities:
1. The acquisition of CASE activities (receiving of permission)
2. Validated Turkish adaptation of CASE activities
3. Choice of parallel activity from CASE activities to POE Method based activities
4. Pilot implementation
5. Regulation of CASE activities
6. Actual implementation

A pilot study was carried out with 25 students studying in 2nd year at Gazi University Gazi Faculty of Education Science Education Program in 2013-2014 academic year spring semester. Written answers given to CASE Project based activities by students were collected and interviews were conducted with students after the activities finished. At the end of the implementation, the points difficult to understand in the materials and worksheets were revealed and incomprehensible ones were corrected. After the elimination of missings in the CASE Project based activities used in the study, the opinion of three experts was asked again and the actual implementation was started. One such activity is shown in Annex 2.

Data Collection Instruments

Scientific Reasoning Skills Test (SRST)

SRST was adapted and compiled by researcher. Because multiple choice tests are shown inadequate to elicit students' conceptual structures, misconceptions, and conceptual knowledge (Griffard, 2001). It was decided to measure scientific reasoning skills with semi-open-ended tests rather than multiple-choice tests. Since there is no open-ended Turkish-adapted test concerning Lawson's (1995) reinterpreting of the stage theory, a new test was developed. Therefore, the Scientific Reasoning Skills Test to measure scientific reasoning skills in more detail wasredeveloped for this study.

As a result of feedback from experts, a pool of 28 questions was obtained by taking 4 questions to each sub reasoning skills from tests developed previously. Language and expression of the test was checked by two Turkish teachers who are experts in the field. This test including 28 questions was implemented to 24 people for the control of intelligibility.
At the end of the implementation problems were identified as it was seen that the sentences in two questions in the test weren't understandable. So these 2 questions were omitted from the instrument. The 26 items of test were compiled from the following sources:

- Four questions were taken from the Test of Scientific Reasoning which was developed by Lawson (1978) and Spearmale Brown reliability coefficient of which was calculated as 0.72 and translated into Turkish by Ates (2002).
- Thirteen questions were taken from Logical Thinking Group Test which was developed by Roadrangka, Yeany and Padilla (1982) for which the Cronbach's Alphareliability coefficient was calculated to be 0.85. It was translated into Turkish by Aksu, Berberoglu and Paykoc (1991).
- Six questions were taken from Test of Logical Thinking which was developed by Tobin ve Capie (1981), reliability of which was calculated as 0,85 and translated into Turkish by Geban, Askar and Ozkan (1992).
- One question was taken from Abstract Operations Period Skills Test (AOPST) which was used by Demirbas and Ertugrul (2012) in their study named An Investigation into the Realization of Skills in the Science and Technology Lessons Expected to be Acquired in Piaget's Abstract Operations Stage.
- Two questions which measure the ability to test hypothesis about unseen events were developed by the researchers.

Questions in the subdimensions of the test are shown in Table 3.

Table 3: Questions in the Subdimensions of the Test

Subdimensions	Questions
Conservation Laws	1, 2, 3
Proportional Thinking	4, 5, 6, 7
Identifying and Controlling Variables	8, 9, 10, 11
Combinatorial Thinking	12, 13, 14, 15
Correlational Thinking	16, 17, 18, 19
Probabilistic Thinking	20, 21, 22, 23
Hypothetical Thinking	24, 25, 26

In the semi-open-ended questions; first, students are asked to find the answer of a question about a situation described as figure and writing by selecting one of the options given and then they're asked to explain how they reached to this answer. For each item, students were expected to provide an answer as well as an explanation of the answer. One point was awarded when both the answer and the explanation were correct; otherwise no points were awarded. Response scores of students for items in this instrument can range 0 to 26.

Validity and Reliability Study of SRST

The test was implemented to a group of 303 people consisting of students who were studying at Gazi University Gazi Faculty of Education Science Education Program. The distribution of the students according to class and gender are given in Table 4. Time was kept until all students completed the test and the ideal time for the implementation of the test was found to be 60 minutes.

Table 4: Students Participating in the Pilot Implementation

Gender	1st Grade	3rd Grade	4th Grade	Total
Female	75	134	53	262
Male	11	22	8	41
Total	86	156	61	303

Cronbach's alpha reliability coefficient related to reliability study of the test was determined as 0,76, which was taken as an adequate reliability coefficient value for the use of the test. Cronbach's alpha reliability coefficients related to subdimensions of the test were as presented in Table 5.

Table 5: Cronbach's Alpha Reliability Coefficient Related to Subdimensions of the Test

Subdimensions	Cronbach's Alpha Value
Conservation Laws	0,75
Proportional Thinking	0,75
Identifying and Controlling Variables	0,75
Combinatorial Thinking	0,75
Correlational Thinking	0,76
Probabilistic Thinking	0,75
Hypothetical Thinking	0,75
Total	0,76

Item difficulty is expressed as the percentage of people who answer the item correctly. The values related to item difficulty indices of the test used in the study are given in Table 6 and item discrimination indices are given in Table 6.

Table 6: Item Difficulty and Discrimination Indices

Evaluation of Items	Item Difficulty Index	Items
Difficult	0,20 - 0.29	7, 10, 11, 16, 17, 19, 24 and 25
Moderately Difficult	0,30 - 0,49	3 and 26
Easy	0,50 - 0,69	2, 4, 9, 12, 13, 15, 18 and 21
Very Easy	0,70- 1,00	1, 5, 6, 14, 20, 22 and 23
Evaluation of Items	**Item Discrimination Index**	**Items**
High Discriminating Power	0,40 and above	22 and 23
Good Discriminating Power	0,30 - 0,39	1, 3, 4, 5, 6, 7, 8, 9, 13, 15, 20 and 21
Moderate Discriminating Power	0,20 - 0,29	2, 10, 14, 18, 24, 25 and 26
Low Discriminating Power	0,00 – 0,19	11, 12, 16, 17 and 19

Based on Table 6, materials with a discriminative power index of 0.19 or less should be removed from the test or passed entirely through the test. Items in the range of 0.20-0.29 must be reviewed; items in the range of 0.30 to 0.39 can be used in the test without correction or with minor modifications; 0.40 and above items are the distinguishing ones and can be taken directly to the test (Kan, 2008). Test items were re-evaluated according to the relevant intervals.

Data Collection and Analysis

SPSS 20 statistics software was used to analyze quantitative data on scientific reasoning skills gained in the implementation of the study. The data of the students' scores were checked whether they provided the necessary assumptions for parametric tests. Later; results were reviewed with ANCOVA analyzes by taking pretest (covariates), posttest (dependent variable) and group (independent variable). Dependent t test was used in comparisons within the groups. The degree of relationship between the variables was examined.

FINDINGS

Pre-test on Scientific Reasoning Skills (Pre-Test)

The first question sought to answer "Is there a difference between the pre-scientific reasoning skills (pre-test) mean scores of students who completed POE Method and CASE Project based activities?".

Since almost intact classes participated in the study, there was a possibility of difference in students capabilities and pre-reasoning skills, characteristics could affect the variables under study. After seeing that the homojenity and normality assumptions were provided to use parametric test techniques, pre SRST scores of the two groups was examined with t test for independent samples whether there was a significant difference between them. As seen in Table 7, pre-reasoning mean scores were found to be statisticaly the same for the two groups.

Table 7: SRST Pretest %, SD and Independent t Test Results

Group	N	$\bar{X}$	S. D.	Sd	t	p
IG_1	47	12,72	3,82	91	-,24	,81
IG_2	46	12,91	3,81			

Findings Belong to Comparison of Pre-Scientific Reasoning Skills in terms of Gender

The second research question is "Is there a difference between pre-scientific reasoning skills mean scores of female and male students?". Independent t test was used for testing whether there was a difference between pre-scientific reasoning skills (pretest) mean scores of female and male students.

Table 8: SRST Pretest Mean Scores Independent t Test Results of Female and Male Students

Group	N	$\bar{X}$	S. D.	Sd	t	p
Female	80	12,74	3,74	91	-,50	,62
Male	13	13,31	4,25			

As shown in Table 8, as p=,62 > α=,05 it was seen that there was no significant difference between SRST pretest mean scores of female and male students. When interpreting these findings, the imbalance between the number of female students and male students should be considered.

Scientific Reasoning Skills Posttest Mean Scores

The third research question is "According to scientific reasoning skills posttest mean scores, is there a difference between the mean scores of IG_1 and IG_2 groups?". After determining conditions for pretest scores to be used as a covariate, pretest scores were included as a covariate in the analysis. IG_1 and IG_2 groups posttest mean scores were analyzed using ANCOVA techniques to learn whether there was a difference.

Table 9: Descriptive Statistics Belong to IG_1 and IG_2 Groups SRST Posttest Scores

Group	N	Mean	Corrected Mean	S. D.
IG_1	47	20,09	20,11	3,38
IG_2	46	17,17	17,15	4,24

As shown in Table 9; according to scientific reasoning skills corrected mean scores,the mean scores of IG_1 was higher thanIG_2. ANCOVA results on whether the observed difference between the scientific reasoning skills corrected posttest mean scores of the groups was significant are given in Table 10.

Table 10: ANCOVA Results For SRST Corrected Posttest Mean Scores of IG_1 and IG_2

SRST	Variance Source	Sumof Squares	Sd	Averageof Squares	F	p
Total	Group	203,90	1	203,90	14,83	,001*

*p<,05

When the ANCOVA results in Table 10 were examined; according to pretest scores of students' IG_1 and IG_2 groups, it was found that there was a significant difference between corrected mean scores of the posttest [F (1,90) = 14,83; p <,05]. In other words, it was seen that scientific reasoning skills of students' in IG_1 group who completed POE based activities developed statistically significantly more than that of students' in IG_2 group who completed CASE based activities.

Findings for Pre and Post Scientific Reasoning Skills Mean Scores of Students Who Completed POE Method Based and CASE Project Based Activities

The fourth question of the researchis "Is there a difference between pre and post scientific reasoning skills mean scores of students who completed POE Method based and CASE Project based activities?"was examined using t-test for dependent samples.

Table 11: Scientific Reasoning Skills Pre and Post Test Dependent t Test Results of IG_1

Group	$\bar{X}$	N	S. D.	Sd	T	p
Pretest Score	12,72	47	3,81	46	-11,03	,001*
Posttest Score	20,09	47	3,38			

*p<,05

As shown in Table 11, according to test results (p=,00 < α=,05) it was seen that there was a significant difference between SRST pretest and posttest mean scores. The mean value of the posttest is higher than that of the pretest. So, this difference also shows that the posttest is higher than the pretest in terms of mean score value.

The difference between pre and post scientific reasoning skills mean scores of students who completed CASE Project based activities was examined with t test for dependent samples. Scientific reasoning skills pre and post test dependent t test results which belong to IG_2 group are shown in Table 12.

Table 12: Scientific Reasoning Skills Pre and Post Test Dependent t Test Results of IG_2 Group

Group	$\bar{X}$	N	S. D.	Sd	T	p
Pretest Score	12,91	46	3,81	45	-6,20	,001*
Posttest Score	17,17	46	4,24			

*p<,05

As shown in Table 12, according to test results (p=,001< α=,05) it was seen that there was a significant difference between SRST pretest and posttest mean scores. The mean value of the posttest is higher than that of the pretest. So, this difference also shows that the posttest is higher than the pretest in terms of mean score value.

Findings for the Difference Between Post Scientific Reasoning Skills Mean Scores of Female and Male Students Who Completed POE Method and CASE Project Based Activities
The fifth research questionis "Is there a difference between post scientific reasoning skills mean scores of female and male students who completed POE Method based and CASE Project based activities?". Descriptive statistics values of female and male students' post test scores are presented in Table 13.

Table 13: Descriptive Statistics Values of Female and Male Students

Group	N	$\bar{X}$	S. D.	Min.	Max.
Female	80	18,16	4,05	6	25
Male	13	21,62	2,93	16	25

According to the descriptive statistics values of posttest scores in Table 13, the mean scores of the female and male students are 18.16 and 21.62 respectively. The standard deviation values are 4,05 and 2.93 respectively. Posttest score values of female students are ranged from 6 to 25. Posttest score values of male students are ranged from 16 to 25. ANCOVA analysis results made to determine whether there is a significant difference between posttest scores of the two groups are given in Table 14.

Table 14: ANCOVA Analysis Results According to SRST Corrected Posttest Scores of Female and Male Students

SRST	Variance Source	Sum of Squares	Sd	Average of Squares	F	p
Total	Gender	122,44	1	122,44	8,35	,01*

*p<,05

When Table 14 was examined, it was found that there was a significant difference between corrected posttest mean scores of female and male students [F(1,90)=8,35; p<,05]. In other words, a statistically significant difference was seen in favor of male students in scientific reasoning skills following the education of female and male students.

Findings for Teaching Method-Gender Interaction in terms of Post Scientific Reasoning Skills of Students Who Completed POE Method Based and CASE Project Based Activities

The sixth research question is "Is there a teaching method-gender interaction in terms of post scientific reasoning skills of students who completed POE Method based and CASE Project based activities?". Descriptive statistics values belong to post scientific reasoning skills of students who completed POE Method based and CASE Project based activities are shown in Table 15, ANCOVA results of comparison made to investigate the interaction effect are presented in Table 16.

Table 15: Teaching Method-Gender Interaction Descriptive Statistics of SRST Scores

	Female			Male			Total		
	N	$\bar{X}$	**S.D.**	**N**	$\bar{X}$	**S.D.**	**N**	$\bar{X}$	**S.D.**
IG_1	40	19,53	3,30	7	23,29	1,70	47	20,09	3,38
IG_2	40	16,80	4,30	6	19,67	2,94	46	17,17	4,24
Total	80	18,16	4,05	13	21,62	2,93	93	18,65	4,08

While testing the assumptions required for ANCOVA analysis which would be made, it was found that posttest score of the dependent variable had a normal distribution (p=,26 > α=,05) with K-S Normality Test. The variances of levels according to group and gender were homogeneous; respectively (p=,18 > α=,05) and (p=,22 > α=,05). In this case the results of ANCOVA analysis were found as in Table 16.

Table 16: Teaching Method-Gender Interaction ANCOVA Results of SRST Scores

Variance Source	Sum of Squares	Sd	Average of Squares	F	p
Group	109,74	1	109,74	8,60	,001
Gender	111,85	1	111,85	8,77	,001
Group x Gender	1,23	1	1,23	,10	,760

As it was seen in Table 16, a significant difference was found between SRST mean scores of IG_1 and IG_2 groups, (F(1,88)=8,60; p<,05). A significant difference was also found between SRST mean scores of female and male students, (F(1,88)=8,77; p<,05). However, the effect of teaching method-gender interaction to SRST posttest scores of students was found to be insignificant, F(1,88)=,10; p>,05. To put it another way, a situation such as one of the methods is more effective in the development of female students and one other is for male students is not the case.

DISCUSSION

In the light of obtained results, it can be said that POE Method has a positive effect on the development of students' scientific reasoning skills.

Discussion Regarding the First Research Question

The result in Table 7 shows that the scientific reasoning skills success of the students in IG_1 and IG_2 groups was at the same level before the implementation. Since groups have similar educational backgrounds, it is expected that their scientific reasoning skills and preliminary information will be at the same level.

Discussion Regarding the Second Research Question

In the result of the analysis made to test whether there is a significant difference between SRST pretest mean scores of female and male students, it was seen that there was no significant difference between the SRST pretest mean scores of female and male students. This result shows that the scientific reasoning skills success of female and male students was at the same level before the implementation.

Discussion Regarding the Third Research Question

According to the findings obtained from SRST posttest scores analysis of students in IG_1 and IG_2 groups, a statistically significant difference was found in the scientific reasoning skills as a result of education that students in IG_1 and IG_2 groups took. As a consequence, the lessons with POE Method was more effective than CASE Project based activities for scientific reasoning skills of students. The obtained results are consistent with previous studies demonstrating that activities prepared with POE Method are more effective in concept teaching by contributing to conceptual change (Koseoglu et al., 2002; Tekin, 2008). POE Method can be explained as discovering the preliminary knowledge in the prediction process, strengthening learning by addressing more senses of students in the observation process and allowing students to compare their predictions and observations in the explanation process (Aydın, 2010).

Among all subdimensions, a significant difference was seen between IG_1 and IG_2 groups inproportional thinking, probabilistic thinking and hypothetical thinking subdimensions in terms of corrected posttest scores. This difference was in favor of IG_1 completing POE Method based activities. For the other subdimensions, no difference was found between IG_1 and IG_2 groups in terms of corrected posttest scores. One of the most important benefits of the POE Method is to ensure the students their active participation in the event to explain the causes of the events. This allows students to bring self-description to the events instead of repeating the information in the book without thinking. Students are faced with the problem situations in the real life. They have the the opportunity to try and observe the comments and explanations they made for the events theoretically (White and Gunstone, 1992, p.58). By this way, students become involved in the learning activities by doing and living.

Discussion Regarding the Forth Research Question

In the result of the analysis made to test whether there was a significant difference between SRST pretest and posttest mean scores that belong to IG_1 group, it was seen that there was a a significant difference between SRST pretest and posttest mean scores. The mean value of the posttest was higher than the pretest. Among all subdimensions, it was seen that there was a significant difference between SRST pretest and posttest mean scores of students in IG_1 group. This was a significant difference in terms of corrected posttest scores. POE is a method used both in teaching science concepts and in conceptual change. One of the most important features of the POE Method is to ensure students their active participation to the event to explain the causes of it. This allows students to explain the events by using their own mental structures instead of repeating the information in the book without thinking. They are faced with the problem situation on the paper in the real life. They have the chance to try the comments and explanations made for the events theoretically (White and Gunstone, 1992, p.58).

In the result of the analysis made to test whether there was a significant difference between SRST pretest and posttest mean scores that belong to IG_2 group, it was seen that there was a a significant difference between SRST pretest and posttest mean scores. The mean value of the posttest was higher than the pretest. It was seen that CASE Project based activities based on research and inquiry were effective in improving abstract thinking and scientific reasoning skills (Shayer ve Adey, 1993).

Among all sub-dimensions except for hypothetical thinking, it was seen that there was a significant difference between SRST pretest and posttest mean scores of students in IG_2 group. This difference was significant in terms of corrected posttest scores. Posttest mean value in hypothetical thinking was higher than the pretest. However, it wasn't a statistically significant difference. Hypothetical thinking was the skill that the students could achieve at the lowest rate. These results are consistent with the study of Demirbas and Ertugrul (2012). In accordance with these results, it is seen that there are not enough emphasis to the development of hypothetical thinking in CASE Project based activities.

In the study in which the analysis of the questions used in the science lessons were made by Ozcan and Oluk (2007), it was found that the rate of the questions for hypothetical thinking skills was less than 1%. Hypothetical thinking skill must be supported by written questions.

Discussion Regarding the Fifth Research Question

When examining the results of the sum of the subdimensions, it was found that there was a significant difference between corrected posttest mean scores in comparison with pretest scores of female and male students. To put it another way a statistically significant difference occurred in scientific reasoning skills after the education that female and male students took. The difference between the average of the groups was in favor of males. It can be said that reasoning skills of male students were more developed compared to female students. In some earlier studies in this field, it was determined that male students have logical thinking skills at a higher level in comparison with female students (Kuzgun and Deryakulu, 2004, p.329; Zarotiadou and Tsaparlis, 2000). Aksu and Berberoglu (1991) emphasize that there is a meaningful relationship between logical thinking level and gender in favor of males. Koray and Azar (2008) reach the conclusion that gender creates a significant difference in terms of logical thinking and male students are more successful.

A significant difference was seen between female and male students in terms of corrected posttest scores of identifying and controlling variables and hypothetical thinking subdimensions. For other subdimensions no significant difference was found between corrected posttest scores of female and male students. Also, according to some research results in literature, it was found that logical thinking skills of students who are preservice teachers does not changedepending on the gender (Yaman and Karamustafaoglu, 2006). In addition; Yaman (2005), Valanides (1996) and Kılcal and Yazgan (2010) conclude that gender has no significant impact in terms of logical thinking.

Correct answers given by male students to questions related to identifying and controlling variables are more than female students. This result is supported by the findings of Yuzuak (2012). Female and male students received the same number of points approximately in the questions which measures probabilistic thinking and correlational thinking skills. This result is also supported by the findings of Yuzuak (2012).

When it comes to the questions measuring combinational thinking, proportional thinking and conservation laws no difference was seen between the mean scores of female and male students. In this regard, it can be said that scientific reasoning skills of female and male students in the study group are similar.

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Discussion Regarding the Sixth Research Question

It was seen that the effect of teaching method-gender interaction to SRST posttest scores of students was insignificant. In other words, SRST posttest scores of students who were taught according to POE Method based and CASE Project based activities doesn't change according to gender or teaching method.

SUGGESTIONS

Teachers should know the cognitive development of the students very well and should do activities for this purpose. In science courses, studies involving scientific reasoning about applied studies can be done. Thus, it may be possible for students to be able to understand abstract concepts better.

In the study, the development of scientific reasoning skills of students was examined by POE Method. The effects of different methods and variables (problem solving, case studies and academic achievement, scientific process skills, and the elimination of misconceptions, etc.) to development of scientific reasoning skills can also be investigated.

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