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THE IMPACT OF THE DEVELOPMENT OF PROSPECTIVE TEACHERS' CRITICAL THINKING SKILLS ON SCIENTIFIC ARGUMENTATION TRAINING AND ON THEIR ABILITY TO CONSTRUCT AN ARGUMENT

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Abstract. *The purpose of this study is to examine the impact of a learning environment created to teach scientific argumentation on the development of critical thinking and argument skills among prospective teacher. The study included 88 2nd grade university students attending Aydin Province Adnan Menderes University, Department of Elementary School Education. An experimental and control group design was used and activity sheets were prepared to develop argument skills in accordance with the topic of "Mechanics". The results of the present study showed that the critical thinking skills among prospective teachers included in the learning environment were higher in comparison to those in the control group, and that critical thinking post-test scores did not show a significant difference by gender in either group. It was also concluded that the learning environment used in the study had a positive effect on the quality of written scientific arguments of prospective teachers.*

Key words: *argumentation, critical thinking, written argument.*

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Introduction

The system of education in schools plays an important role in the acquisition and development of various thinking skills. However, it is seen that today's system of education does not allocate adequate space to methods and techniques that would help to develop cognitive thinking skills among students (Özdemir, 2005). In addition, it is necessary to train students in critical thinking skills so as to create democratic and humanistic classroom environments, to enable students to acquire scientific literacy and to see paradigm shifts in scientific knowledge. Therefore, the approach used as the basis for scientific education should be chosen in parallel with this purpose (Vural and Kutlu, 2004). Based on a review of the literature, it can be said that one of the most appropriate strategies for teaching these new paradigm shifts and mental thinking skills is scientific argumentation (Köseoğlu, Tümay and Budak, 2008). Driver, Newton and Osborne (2000) recommended that argumentation theory should be integrated into education because it aims to enable students to acquire the skill of "knowing" not only as knowing what the event is, but also "its relationship with other events, why it is important, and how the world is seen from this perspective". The present study firstly tries to explain the expressions of argumentation, scientific argumentation and critical thinking skills, and discusses the relationship between critical thinking and argumentation.

Argumentation

Toulmin (1958) defines argumentation as the process of associating ideas with appropriate reasons, according to the available data. Trend (2009) expresses argumentation the entirety of scientific dialogues, which individuals use to learn scientific information and to increase the ability to explain this knowledge within a cause and effect relationship. Aslan (2010) emphasizes the need for students to use argumentation processes to construct scientific knowledge and form correct mental models.

Driver et al. (2000) define argumentation process as "a construction of prediction". According to this definition, producing a structure by attributing terms and concepts from simple thoughts to particular conclusions is regarded as a creative process. These conclusions are expressed as follows: "when you complete the construction of your building, your thoughts will become organized in a way". Accordingly, it regards "argument" as a combination of scientific knowledge and ideas.

In short, argumentation is described as individuals' justifying their ideas through persuasive evidence and, accordingly, using this evidence to convincing others of the validity of their ideas. That is to say, argumentation refers to the capability to think about a scientific topic like a scientist by expressing and discussing thoughts in a written or oral form.

Science Education and Argumentation

It is still peremptorily thought in science education that nature and science can be reflected via observation and experimentation. However, it is necessary to concretize science education practices by socially constructing scientific knowledge in order to provide students with an adequate science education. Experiments and observations conducted for this purpose fail to satisfy this requirement. Students should also question scientific knowledge, which is always changing, because science is the most conscious and rational method used to question the world by using causes as evidence and reasoning about the evidence (Trend, 2009). Therefore, in recent years, the most important objective in science education has been enabling each individual to become scientifically literate and to understand the changing paradigms of scientific knowledge. This radical change in science education aims to make students conscious individuals, and better able to make decisions about certain current socio-cultural topics (Köseoğlu, Tümay and Budak, 2008).

Developing understanding of science concepts and ideas is of great importance to scientific literacy. Therefore, students should be made to "interact with ideas" (Osborne, 2002). Accordingly, they will question the pre-existing models in their minds, they will examine the models of their friends, and they will create an argument to defend their own models (Aslan, 2010). This change of perspective has prompted important pedagogical studies, which have also changed in-class activities, among which argumentation activity is particularly well-known (Trend, 2009).

Regarding the need for and the importance of argumentation in science education, Osborne (2005) states that argumentation is important for:

a) Developing the skill of analyzing and engaging in arguments guiding the construction of scientific explanations
b) Developing the skill of critically evaluating multiple alternatives.

According to Driver et al. (2000), there are three important products for learners in the argumentation process in science classes. They are developing conceptual understanding, developing the skill of researching, and developing understanding of scientific epistemology.

a. Developing Conceptual Understanding: This is used to create awareness among students about paradigm shifts, which are in the very nature of science. To achieve this, knowledge should not be "given" directly to learners as being considered absolute. Learners should be taught the "ways of seeing" to reach scientific knowledge. In this way, learners can explain their own observations by presenting their views and warrants.

b. Developing Research Skills: It is not adequate that learners reach a theory or a result set by scientists just through data. Instead, they should make their possible suggestions, and then

they should defend their comments in each argument in the light of appropriate evidence. Scientific studies that are constructed in this way, based on a planned methodology and appropriate experimental studies, require more concentration, more comments and more time to complete the operations given. Arguments are created at the end of these operations.

c. Understanding Scientific Epistemology: It is of great importance that students use language not only for understanding science concepts or theories, but also as claims in which they will put forward this knowledge. In short, if it is thought that evidence and argument should take a central role in "developing an understanding" in epistemology and science, science education should move from an individual structure to a multiple comments structure suggested (different view of each student) (Trend, 2009).

Thoughts start to develop in contemporary topics and discussions due to argumentation processes, which teach scientific methods of thinking and of discussing issues. Accordingly, learners begin to take into consideration only what is important about science. It is aimed to develop self-confidence in the matter of creating an argument by allowing students to explain their arguments in different situations. Development of self-confidence enables students to be more skilled while making decisions in their lives, defending their ideas in democratic environments, and expressing themselves (Osborne, Erduran and Simon, 2004). Moreover, due to the argumentation process, students can critically examine the events and situations around.

Critical Thinking and Argumentation

Critical thinking skill is defined in different ways within the literature, demonstrating that critical thinking has many different perspectives. Some of these definitions are as follows:

According to Özdemir (2005), critical thinking refers to mental or intellectual skills involving an individual's intent to obtain evidence for the accuracy, reliability and truth of claims put forward by oneself or others concerning a particular topic. These skills promote qualities such as straightforwardness, honesty, consistency and accuracy among individuals.

Osana and Seymour (2004) state that critical thinking skill is managed by scientific and statistical principles. They give meaning to the term "critical thinking" in such a way that it includes both evidential argumentation and statistical reasoning processes.

Considering these definitions, critical thinking is a high/level means of thinking, which allows individuals to question assumptions, concepts and phenomena, and to create valid arguments by basing contextual knowledge about a particular topic on strong causal evidence. On the other hand, individuals with the skill of critically evaluating the strength of arguments about a concept or phenomenon directed to them or created by themselves enables clashes of ideas to become a quality "argumentation" process. Accordingly, critical thinking also develops the skills required for establishing effective inter-personal communication. In such a quality argumentation process, "critical thinking" occurs as a mental skill to enable participants to determine the validity of the concept under discussion and to learn it in depth within the context of cause and effect relationships.

The skill of thinking about a topic from different perspectives should be acquired by students for them to consider possible effects of their and other people's ideas and to be aware of errors and bias the individual can fall into in his own thinking process. To develop this skill, students should participate in debating exercises in which they can question and evaluate different aspects of the events (Cohen, 1993; cited by Kökdemir, doctoral dissertation, 2003, p. 50). These exercises allow provide practice in developing their own skills by creating environment in which they can perform significant tasks via their own arguments created by reasoning (Driver et al., 2000).

Examining the literature, it is seen that critical thinking and argumentation are similar. The skills involved in Kökdemir (2000; cited by Kökdemir, 2005)'s critical thinking process and Toulmin (1958)'s process of creating an argument are compared in Table 1.

Table 1. Comparison of Skills involved in Critical Thinking and Creating an Argument.

Critical Thinking Process Skills (CTPS)	Skills of Creating an Argument (SCA)
Ability to capture the difference between proven truths and claims asserted	Ability to put forward an opposing claim (with warrant + data)
Ability to test the reliability of data sources	Ability to determine and to be sure about the sources of data pertaining to the claim
Ability to separate unrelated information from evidence	Ability to determine limitations of the claim
Ability to be aware of prejudices and cognitive errors	Ability to be persuaded by the opposing rebuttal put forward against the claim and to question one's own claim
Ability to notice inconsistent judgments	Ability to notice weak or wrong warrants failing to explain the difference between an opposing claim and its data
Ability to ask effective questions	Ability to demand an explanation for an opposing claim and to ask for supporting evidence
Ability to use spoken and written language effectively	Ability to use the skill of creating an oral and written argument: ability to use data and warrants that support one's claim in sentence patterns (written or oral)
Meta-cognitive skill by means of which the individual gets aware of his own ideas.	Ability to notice one's own claims, data and warrants. Ability to be aware that one stands by the claim puts forward (with its warrants, rebuttal or data), that one knows nor only know the topic but also reasons to support the claim The individual will have the ability to rebut the opposing claims to the extent that he knows which claim he defends and why.

The reason for comparing Kökdemir and Toulmin is developing and using The California Critical Thinking Dispositions adapted to Turkish by Kökdemir (2003) and activity sheets that include Toulmin's (1958) basic skills for creating an argument. According to Toulmin (1958), there is a difference between data and warrant concerning it, and between a proven claim and an asserted claim in terms of argument quality. The ability to capture this difference is seen also in critical thinking process skills (CTPS). While determining sources of data justifying the claim, citing them as evidence, and being sure about reliability of sources allow for finding strong evidence for arguments in SCA, they are seen as ways of determining the reliability of sources in CTPS. According to SCA, it is necessary to separate unrelated information from evidence in order to determine the limitations of claims, as stated in CTPS. In this way, conditions will be determined under which claims would be accepted as being true. The individual should have the ability to be aware of prejudices and cognitive errors mentioned in CTPS in order to develop openness to being persuaded by the opposing rebuttal and questioning his own claim during mutually created arguments. That is because being aware of these differences will also enable an individual to reach proven truths. The ability to be aware of inconsistent judgments, stated in Kokdemir, will enable the individual to be aware of incorrect/deficient evidence in opposing ideas expressed during arguments. Individuals with the abilities to ask effective questions and to use spoken and written language effectively will have higher written, oral and (in particular) argument skills. Effective questioning enables an individual's communication to be stronger, and effective use of language enables better expression of one's ideas. If the individual develops meta-cognitive skill, through which one becomes aware of one's own opinions, then the individual has an awareness concerning their own claims. Overall, it is seen that the skills to be acquired in both processes are quite similar. Toulmin (1958) states that argumentation process supports the development of critical thinking skills. Based on this view, Osana and Seymour (2004) stated that their primary educational objective while developing the rubric based on argumentation and reasoning was to develop critical thinking skills of participant students, which are complicated within the scope of educational problems. In this critical thinking model, the following choices were preferred in order to assess the thinking skills of students:

a) Ways of understanding and using evidence while reasoning
b) Understanding the value of research in reasoning process
c) The ability to think of alternative points of view.

In critical thinking skills, "evidence" is considered as the first criterion. The importance of this concept as a component for reasoning and argumentation dates back to a long and important historical process. Several researchers mention that the role of argumentation in the fields of reasoning and critical thinking, and in student knowledge and guiding the class, still continues (Osana and Seymour, 2004).

Problem of Research

What is the impact of the scientific argument constructing training on the development of argument constructing and critical thinking skills of prospective classroom teachers?

Sub-problems:

1. Is there any significant difference between the pretest and posttest results of prospective classroom teachers in both experimental and control group in terms of their critical thinking skills before and after getting the argument constructing training?
2. Is there any significant difference between the pretest and posttest results of prospective classroom teachers in the experimental group in terms of their argumentation construct skills after getting the argument constructing training?

Research Focus

The primary objective in the study by Gold, Holman and Thorpe (2002) was to collect points of view and argument analysis concerning storytelling within a personal development module; and to determine how critical thinking takes shape in this process. There are two reasons for combining a storytelling module with argument analysis. The first reason is developing critical thinking skills of persons by means of argument analysis, and the second reason is helping storytellers to create arguments that appear significant to them and reflect their daily practices. In other words, stories and persons can create arguments that oppose or support a claim. Although the focus of the study is how a teaching module is formed and how it facilitates critical thinking, the findings indicate that a combination of argumentation analysis and story-telling develops many points of view concerning critical thinking (Dimensions such as critique of knowledge and author can be given as examples.)

Osborne et al. (2004) reported that critical thinking skills of students should be developed in order for them to develop a point of view about a topic in their in-group works, to form their evidence or to create counter-arguments against opposing claims and points of view. Accordingly, an individual who could not acquire critical thinking skills would not be expected to present strong arguments, evidence, warrants and rebuttals.

At the present time, students are expected to be creative and responsible individuals who ask questions, think about and investigate the warrant of an event, identify contradictions and inconsistencies, make good observations and make appropriate deductions from observations, think scientifically, criticize, produce, know means of accessing information, have decision-making skills, can express themselves; do not simply memorize information but know how to access, use, share and produce the information; that is, who have the skill of creating an argument and critical thinking skills (Akar, 2007; Akbıyık and Seferoğlu, 2006). Teachers, who are expected to develop these skills among students, must surely have these skills. As students firstly encounter primary education teachers and classroom teachers in their educational lives, the present study aims to develop prospective classroom teachers' skill of creating an argument and determining the impact of these skills on their own critical thinking skills.

Methodology of Research

General Characteristics of Research

In this study, the pre-test post-test experimental model with a control group was used. When random assignments cannot be made, true experimental research cannot be done. In its place, quasi-

experimental research is used, which embodies the characteristics of experimental research, excluding random selection and assignment of participants (Charles, 1998:308). The semi-experimental model was used, with the students' score averages used to determine the control and experimental groups.

Lessons in control group were taught by question-answer techniques and teacher and class book centered lesson plans which were prepared according to classical learning model. In control group, teacher centered classical learning model, in which the teacher is active and the student is passive in class experience and in educational activities in that those experiences are given, was performed. The experimental group was applied developed activity sheets for 6 weeks.

Sample of Research

The experimental study included 88 second-grade elementary school prospective teachers (experimental group (N=44) and control group (N=44)) attending Aydın Province Adnan Menderes University Department of Elementary School Education in Turkey. The sample consists of prospective teachers taking physics course in second grade. The prospective teachers' final score averages used to determine the control and experimental groups.

Instrument and Procedures

The study used the "Concept Test on Unit of Force and Motion" developed by the researchers and the California Critical Thinking Dispositions Inventory (CCTDI), whose adaptation, validity and reliability for higher education students were studied by Kökdemir (2003) in a doctoral study titled "Decision Making and Problem Solving Under Uncertainty".

1. Concept Test on Unit of "Force and Motion"

Firstly, the following concept test was prepared as part of the "Mechanics" topic of the science course:

Mehmet and Özgür discuss under which situations work is done.
Mehmet: We must move in accordance with the force we apply in order to say that we do work.
Özgür: No, we do work even if we do not move in accordance with the force we apply.
Please indicate which of the following expressions support the ideas of Mehmet and which of the following expressions support the ideas of Özgür, and explain why a particular expression supports the related researcher by filling in the blanks.

1) A child carrying a bag in his hand without swinging it on a horizontal road did work.
a- This supports Mehmet's ideas.
b- This supports Özgür's ideas.
That is because; .....

2) We do work when we lift an object on a horizontal surface at a constant speed.
a- This supports Mehmet's ideas.
b- This supports Özgür's ideas.
That is because; .....

3) A person shooting arrows does work when he draws the string of the bow.
a- This supports Mehmet's ideas.
b- This supports Özgür's ideas.
That is because; .....

The answers of written arguments in the concepts test were evaluated with rubrics developed by researchers.

2. Critical Thinking Survey

The present study employed the California Critical Thinking Dispositions Inventory (CCTDI), which emerged as a result of the Delphi project organized by The American Philosophical Association in 1990. Adaptation, validity and reliability studies were conducted by Kökdemir (2003) among higher education students as part of a doctoral thesis titled "Decision Making and Problem Solving under Uncertainty". Students were asked to make assessment via a six-part scale ranging from "I completely agree" to "I do not agree at all". The scale has 7 theoretically determined and psychometrically tested sub-scales; however, the scoring system made up of all these scales is used to determine critical thinking dispositions (Facione, Facione, and Giancarlo, 1998; cited by Kökdemir, 2003). Adaptation studies of the scale, originally comprising 7 dimensions and 75 items, were conducted by Kökdemir (2003), and the scale was reduced to 6 dimensions and 51 items. Examining factors that make up the revised 51-item CCTDI scale and items within these factors, it is seen that this factor structure is not very different from the original scale.

The internal consistency coefficient (alpha) of the new scale comprising a total of six dimensions and 51 items was found to be .88. The total variance explained by the scale is 36.13 %. In order to determine the critical thinking dispositions of students, raw scores were formed for each sub-scale by subjecting the responses to a scoring between 1 and 6; these raw scores were divided into the number of questions, multiplied by10 and converted into the standard score, which has a minimum of 10 and a maximum of 60 . Possible minimum and maximum values are constant for all sub-dimensions (Kökdemir, 2003).

Facione, Facione and Giancarlo (1998; cited by Kökdemir, 2003) state that persons scoring lower than 40 for any sub-scale have low critical thinking dispositions in this dimension, and persons scoring higher than 50 have high critical thinking dispositions. Accordingly, when CCTDI – R is considered as whole, it can be said that persons with scores lower than 240 (40 x 6) have low general critical thinking dispositions, and persons with scores higher than 300 (50 x 6) have high critical thinking dispositions. As the original scale comprises 7 dimensions, Facione, Facione, and Giancarlo (1998; cited by Kökdemir, 2003) reported that these values are 280 (40 x 7) and 350 (50 x 7) respectively. Students with high, medium and low critical thinking dispositions were determined for the study group, taking into account the low and high scores that students achieved on the scale.

Preparation and Application of Activity Sheets

Activity Sheets for Developing and Applying the Skill of Constructing and Using an Argument:

Frameworks suitable for the topic of mechanics were chosen from those in Osborne et al. (2004) and activity sheets were prepared according to these frameworks. The following frameworks were chosen for the present study:

- Classification Activity
- Having the theories raced
- Predict-Observe-Explain (POE)
- Diagnostic Test Item

Although different practices were conducted in each framework used in the activity sheets, blanks were asked to be filled up (App. 1).

A Sample Activity:

At the beginning of the lesson, questions such as "*What does argument mean? Why is there a need to construct an argument?*" were explained by giving examples from scientists. After the importance of constructing an argument was explained, the topic of mechanics was introduced. Activity sheets on the topic of mechanics were distributed to the students. As an example, the activity in App. 1 was administered first to 2 students and then to 4 students. After activity sheets were distributed, students were told what they had to do in this activity. Firstly, two different ideas were read to the class from

the activity sheet. By emphasizing the difference between them, the students were required to consider which one could have made a correct argument. Students were first asked to complete the first page of the activity sheet, providing a written explanation of which argument they support and why. Students were also informed that they could find supporting evidence from additional papers in order to explain their reasoning more easily. Students were given 15 minutes for this practice example. Discussions made by each group were observed by the researchers. There were groups supporting both arguments and groups supporting neither of the arguments. After 15 minutes, students were asked to complete the blank sections on the back page. Here, additional evidence was used for the "reasons" section. This part was completed within 10 minutes, and was followed by the process of discussing the activity in the classroom environment. It was observed that the skill of constructing an argument emerged during this session, since each group had quite different ideas and opinions. Students were asked which pieces of additional evidence they used to inform their opinions, and additional examples were taken from the students. Following the discussion process, lasting for approximately 15 minutes, the correct argument was explained together with examples and reasons for correctness. Finally, the processing of activity sheet was completed with the question "*which one of the two arguments does all of the evidence support?*"

Though the application of other activity sheets varies according to their frameworks, the focus point of the activities is that great importance is attached to small group and large group discussions.

Data Analysis

Data obtained from the scale of values were analyzed in SPSS 11.5 , using frequency (f), percentage (%), average (X), standard deviation (SD) and one-way MANOVA, and by using univariate ANOVA as a tracking test for each dependent variable. The independent variable of the study is the method employed; dependent variables of the study are the state of application and critical thinking skill scale; and the control variable of the study is the university where prospective teachers receive education. Assumptions of MANOVA were tested before examining the effects of each independent variable on the dependent variables. It was determined by means of Levene test that dependent variable scores displayed univariate and multivariate normal distribution and that variances were homogenous for each dependent variable. Homogeneity of variance-covariance matrixes was determined via Box's M test. Kittler, Menard, and Phillips (2007) reported partial eta-squared values as being low for $\eta^2 \leq 0.01$, medium for $\eta^2 = 0.06$ and high for $\eta^2 = 0.14$. A partial eta-squared concerning class-level effect was found to be $\eta^2 = 0.063$ in the present study. All data analysis used a statistical significance level of 0.05.

Written arguments comprising the answers given by students to the concept test were analyzed via a rubric developed by the researchers.

Rubric Development Process

During the application, the researchers particularly observed evidence of the given limitations with regard to the oral arguments presented by prospective teachers. In the first stages of the application, students had difficulty in expressing themselves and therefore utilized body language in their arguments. It was observed that students created better arguments in small group argumentations in comparison to large group argumentations. However, they did not follow any particular order (claim, data, warrant, rebuttal, etc.) while creating their arguments. They did not make use of expressions such as "because, for, but, and...", which significantly connect sentences to one another and lead to the construction of quality arguments; and they tried to find examples from their daily lives to explain and support the claim given. These methods seemed to be better structured in their written arguments. However, certain strong sides were also seen in oral arguments, such as explaining a claim with more than one example and using stronger data during in-group argumentations. Accordingly, the researchers developed their own rubrics in the present study.

The concept test was administered as a pre-test and post-test to evaluate the participants' written arguments. The answers were analyzed via an analytical rubric developed by the researchers. Criteria

in the rubric were formed by examining elements defined by Toulmin (1958) and the rubric developed by Osana and Seymour (2004). Elements defined by Toulmin (1958) to exist in an argument are as follows:

- *Data:* These include the phenomenon to which persons resort to support their arguments. Data are based on assumption in problem situation.
- *Claim:* This is the conclusion whose merits are to be established.
- *Warrants:* These include reasons (rules, principles… etc) suggested to verify the links between data and description or result of information.
- *Backing:* These are generally bases serving the verification of particular warrants.
-

The presentation of simple argument structures within sentences is at the heart of this model:
because (data) . . . for (warrant) . . . In total (backing) . . . Therefore (result)
Toulmin (1958) defines two other features for more complicated arguments:

- *Limitations:* They express the conditions under which the claims are accepted as valid; they present the limitations in the explanation.
- *Rebuttals:* They express the conditions under which the claims are invalid.

Within the rubric, criteria were determined for "formation of claim, data and warrant, and use of conjunctions and additional concepts (evidence, limitation and backing)", and expected performances were expressed at 5 levels (0 (inadequate), 1 (improvable), 2 (medium), 3 (good) and 4 (very good)) (App.-2). In the analysis of written arguments, three students were chosen from each group of students with low, medium and high critical thinking skills, determined according to their score in the CCTD-I post-test. The answers (written arguments) given by these students to the pre- and post-concept test were analyzed via the rubric developed by the researchers.

Results of Research

First sub problem:

Average values of dependent variables related to the application status of the study were compared by means of one-way MANOVA.

Examining results of MANOVA conducted on pre- and post-test scores showed a statistically significant difference between students in both the experimental and control groups [Wilks' Lambda =0.881, $F(2, 85)=5.763$, $p<0.05$].

Average and standard deviation values concerning pre- and post-test scores and results of one-way ANOVA conducted on pre- and post-test basis according to whether students received argumentation training are given in Table 3. Accordingly, while no significant difference was found in pre-test scores [$F(1, 86)=.86$, $p>.05$], the post-test scores showed a significant difference according to whether students received argumentation training [$F(1, 86)=5.77$, $p<.01$]. Post-test scores of students in the experimental group were significantly higher than those in the group in which argumentation training was not conducted.

Table 2. Average and Standard Deviation Values of Pre- and Post-Test Scores according to the Method Employed, and ANOVA Results.

	Method	n	Mean	SD	df	F	Sig.
Pre-test	Argumentation	44	191.273	18.497	1-86	0.859	0.357
	Traditional	44	194.659	15.661			
Post-test	Argumentation	44	203.886	18.842	1-86	5.777	0.018*
	Traditional	44	192.114	26.469			

Second sub problem:

Written arguments in the concept test were analyzed via the rubric developed by the researchers.

Analysis of the first question in the concept test according to high, medium and low level students' (determined according to scores taken from critical thinking scale) skill of creating an argument:

Table 3. First question analysis.

Student	Pretest	Posttest
A_1	He/she could not make any comment= 0 point	*Work=W=F.x(evidence)* *That supports the ideas of Mehmet (claim). That is because Ozgur says that we do work even if there is no move in accordance with the force (claim)* *He does not swing the bag.* → *That is to say, there is no move (data-1)* *There is force.* → *Carriage of the bag (data-2). There is no work done here (warrant)* This student used 2 data to support the claim of Mehmet. In these data, he/she analyzed the situation given in the question and divided them into pieces. He/she reached the components to define the physical work by finding the physical term for each piece. He/she determined the cause and effect relationship between data and the claim by using the formula that defines work. (claim+data1+data2+warrant+evidence= 4+4+3+4+4 (as he/she used "because")+1 (as he/she recognized the terms of move and force)=20 points
B_1	He/she could not make any comment.=0 point	*That supports the ideas of Özgür (Claim), because he does not apply any force to the bag. (Incorrect Data1) The bag just moves with this person. (weak data 2) (weak warrant)* This student supports the ideas of Özgür using two data that are incorrect and weak, respectively. However, the fact that his/her data do not have adequate quality and he/she cannot establish the relationship between data and the claim may result from the use of a weak warrant. Claim + incorrect data 1+weak data 2+weak data=3+1+2+2+4 (as he/she used "because")=12 points
C_1	He/she could not make any comment.=0 points	*That supports the ideas of Özgür (claim), because the bag does not move. (a weak data)* This student made an inadequate justification by presenting a weak piece of data to support his/her claim. Claim + weak data=2+2+4 (as he/she used "because")=8 points

The written arguments of the students ranked "low, medium and high" level according to critical thinking scores for the 1st question were analyzed by means of the rubric developed by the researchers. Accordingly, A_1 students represent high level, B_1 students represent medium level and C_1 students represent low-level abilities. It was determined that some students at medium and low level had misconceptions concerning this question. For example, B_1 students tried to explain his/her claim by using an incorrect data. All of the students with a high level of ability employed an opposing idea, 2 data and a warrant in their explanations. Additionally, it was observed that some of the students wrote the formula to calculate "work" as evidence to support their answers. Students in the B_1 group forward 2 weak data and 1 weak warrant. It was determined that other students who were determined to be at medium level were at the same level as B_1 in terms of their responses to this question, although there were some differences in the number of weak data and weak warrants employed in their explanations. C_1 students tried to explain his/her claim by means of weak data. Some of the other students at low level used a weak warrant instead of weak data. It was seen that some of these students had incorrect warrants and incorrect data as well as misconceptions.

Analysis of the second question in the concept test according to high, medium and low-level students' (determined according to scores taken from critical thinking scale) ability to construct an argument;

Table 4. Second question analysis.

Student	Pretest	Posttest
A_2	*That is because the object moved in the same direction as the force we applied.* S student supports the claim of Mehmet. It is seen that he/she has an inadequate argument as he/she expresses his/her warrant by repeating the claim of Mehmet. Claim + weak warrant=2+ 2=4 points	*That supports the ideas of Mehmet (Claim), because ascending force is applied against gravity (Warrant) and the object ascends in the same direction as the force affecting it.(Data)* Student justified his/her claim by combining data and his/her warrant with the conjunction "and". In this warrant, he/she explained the work done via his/her special definition by stating that the work is done against gravity. Claim + data + warrant= 4+3+3+4 (as he/she used "because")+1 (as he/she used the conjunction "and") +1(as he/she could define the work done against gravity) =16 points
B_2	He/she could not make any comment =0 points	*That supports the ideas of Mehmet. (Claim)* *The force is applied (weak data 1) and there is movement when the object is lifted. (weak data 2)* This student tried to support the claim with two weak data. However, the example situation could not be explained with adequate data. Claim + weak data 1+weak data 2= 3+2+1(as he/she used "and" conjunction)+4 (as he/she used "because")=10 points
C_2	He/she could not make any comment =0 points	*That supports the ideas of Özgür. (Claim) That is because, according to Özgür, we do work though we lift the object, though we do not move (weak data).* This student marked the incorrect claim as he/she had a misconception. However, considering his/her level of expressing herself/himself; He/she tried to justify his/her claim with a weak data. (He/she expressed lifting the object not as a movement) He she/remained incapable of establishing a data-claim relationship and presenting warrants. Claim + weak data=2+2+4 (as "because" was used)=8 points

Students' written responses to the second question in the concept test were analyzed with the rubric developed by the researcher. Accordingly, A_2 students formed an argument made up of data-claim and warrant. Other high level students allocated space to the expression "*the force affecting the object is on the y axis, but the object moves towards the x axis*" as well as presenting an argument comprising these three components. This expression may be evaluated as presenting the warrant with a different point of view "*That means even that we do work against gravity. There is both a force, and the object moves in the same direction as the force we apply*". That kind of an expression forms a "backing" concept. The B_2 student explained his/her claim with 2 weak data. This level of constructing an argument was also observed in other students at medium level (certain differences were observed in the number of weak data and weak warrant). In the written argument presented by C_2 students, just one weak data was encountered concerning his/her claim. Other students at low level showed the same level of capability apart from differences in the presence of weak data and weak warrant. In the answers provided to this question, none of the students at any of three levels showed any misconception.

Analysis of the third question in the concept test according to high, medium and low-level students' (determined according to scores taken from critical thinking scale) skill in creating an argument;

Table 5. Third question analysis.

Student	Pretest	Posttest
A_3	That supports the ideas of Özgür. (claim) That is because it applies a force. (a weak warrant) This student explained his/her claim with a weak warrant. He/she could not make an adequate justification. Claim + weak warrant =2+2+4(as he/she used "because")=8 points	*Work=force*distance (evidence)* *That supports the ideas of Mehmet. (claim) That is because the location of the spring changed (data 1) and this was done in accordance with a force. (data2) (warrant) It is not whether we do work or not that matters, but the state of the spring. That means that it does work. (Qualifier)* This student used 2 data, evidence and backing to support the claim of Mehmet. He/she put forward his/her warrant by expressing the relationship between his/her data and sample situation and claim. The formula of the work is there as an element to support his/her warrant. He/she separated two situations from one another by stating in his/her qualifier sentence that attention must be paid attention to whether work is done when the person in the example draws the bow, and not to whether "we" do work at this moment. claim+data1+data2+warrant+qualifier=4+4+3+2+4 (as he /she used the conjunction "because")+1(as he/she used the conjunction "and")=17 points
B_3	He/she could not make any comment. =0 point	*That supports the ideas of Mehmet. That is because, there is the direction of spring (weak data1) and movement of the spring (weak data2).(Weak warrant)* This student uses 2 weak data to support the claim of Mehmet. However, he/she remains incapable of establishing the cause-effect relationship between these data and the claim. (because of the weak warrant) Claim + weak data1+weak data2+weak warrant =3+2+2+4(as he/she used "because") +1(as he/she used the conjunction "and") =12 points.
C_3	He/she could not make any comment. =0 point	*That supports the ideas of Özgür. (Claim) That is because a force just like in the expression of Özgür was applied. However, there is no movement in the same direction as the force. (weak data)* This student marked the incorrect claim due to a misconception. However, he/she expressed the claim he/she defended as follows: By giving Özgür's expression as evidence, he/she stated that there was a force applied in the example, but there was no movement. However, he/she could not associate the example and these data. Claim + weak data=2+2+4(as the conjunction "because" was used)+2(he/she could say "just like in the expression of Özgür)=10 points

Evaluating the written arguments of students concerning the 3 questions in the concept test, A_3 students, categorized as high level, used two data items, warrant and limitations when constructing their argument. The same level of skill in constructing an argument was also found in other high level students. The movement of the spring was explained by some students in a more detailed manner and, accordingly, stronger data were encountered. For instance, "*As soon as he/she drew the bow, he/she pulled back the arrow as well*" "*As soon as he/she drew the bow, a force occurred towards himself/herself. There is also a movement. The movement is in the direction of x. So, he/she did work*". Apart from that, one student justified the problem from a different point of view: "*There is a potential of flexibility here. The energy is defined as the ability to do work. However, the work was not done, according to Özgür's definition*". B_3 students created an argument comprising two weak data and weak warrant. Other medium level students showed similar levels of ability (there is a difference in the number of weak warrant and data used.). The C_3 students, representative of the low level, expressed their claims using weak data. The understanding of this topic displayed by other low level students was similar to that of C_3 student. There were also some students who did not show misconception but made their justification using weak data or warrant.

Discussion

The impacts of scientific argumentation training on the development of prospective teachers' critical thinking skills and on their ability to construct an argument are discussed below:

1. *It was determined that training in constructing an argument increased the development of critical thinking skills among prospective classroom teachers.* According to the findings, students scored higher on the critical thinking posttest following the argumentation process they went through. In parallel with this result, Gold, Holman and Thorpe (2002) found that critical thinking skills developed during the process of forming an argument and making analysis. They concluded that the combination of argumentation analysis and storytelling developed many points of view concerning critical thinking: e.g. critique of knowledge, critique of author etc.

   Clayton and Gautier (2006) also made an argumentation application including deliberate orientations on the topic of The World System taught within a university science course. Via evidential precedents they gave during the argumentation process they formed on the "Climate System of the World", students participating in this study learned about global climate change, principles of argumentation technique, and how to develop their critical thinking skills through this technique.
2. *It was determined that training in constructing an argument had an effect on students' skill in creating an argument.* A pre and post concept test was administered to students and their written arguments were evaluated within the rubric developed by the researchers. Although a great majority of students did not make any comment about the questions given in the pretest, they displayed differences in their posttest results. Accordingly, it was determined that their skill in creating an argument had improved following training. Students in the experimental group developed their skills in constructing an argument in terms of justifying the claims they put forward. Examining these arguments, it was seen that some students had misconceptions. Even so, these written arguments were also included in the analysis because, while using this model, it was necessary to describe the speeches of students (arguments consisting of claims, data and warrants). However, what makes an argumentation high quality is the presence of an argument with deceptive data or warrants. According to Osborne (2005), arguments are collected under three groups: simple claims, arguments with verification, and arguments with verification and rebuttal. Therefore, what is defined as "the skill of creating an argument" is students' ability to use the abovementioned elements in their own arguments. The fact that students participating in the present study successfully constructed an argument (claim + data + warrant), though sometimes incorrect ones, at the end of the application despite not being able to make any comment about the questions given before the application means that they acquired this skill. A follow-up study is planned, which will interview with students with misconceptions in order determine the source of these misconceptions.

While analyzing the written arguments of students using the developed rubric, criteria such as the presence of claim, data, evidence, limitation, backing and warrant (weakness or strength of these elements) and the use of conjunctions such as "for, because, and, for example..etc." was taken into consideration. In accordance with the present study, Osana and Seymour (2004) also developed a rubric for argumentation analysis. In their study, while analyzing the arguments created by prospective teachers in the application, development of their critical thinking skills was also examined through this rubric. In the present study, qualitative data analysis indicated that participants had developed their skill of focusing on evidence of concepts pertaining to a topic. For instance, at the end of the application, it was found that students had improved their skills of using research findings while making decisions about complicated problems encountered in school life or social life. In addition, it was seen that they made progress in differentiating between evidence type and evidence quality in comprehending the nature of a weakly structured problem. Overall, it was seen that students developed their opinions about the evidence more, and became better at combining related concepts to present evidence to support an opposing claim.

One of the limitations of the present study is that no rebuttal was encountered in the arguments of the students participating in the application. However, rebuttals are considered an important element in developing a better quality argument and to show a higher level of argumentation quality (Osborne et al., 2004). The use of rebuttal element in argument demonstrates that the student can construct a high level argument defined by Toulmin and Osborne. This limitation of the present study is thought to derive from the limited training on argumentation principles. Examining the literature, it is seen that students with high-level argumentation skills received a long period of argumentation training and examined many topics in this way. Osborne et al. (2004) conducted a two-stage process lasting for 2 years in primary schools in London. In the first stage, they developed strategies and materials to undertake argumentation within the classroom, to increase the argument capacities of students, and to raise awareness among teachers on the issue of argumentation. In the second stage, they formed classrooms including groups in which teachers receiving training would lead scientific or socio-scientific argumentation. Even at the end of this process, only a few students were found to reach the 5th level according to Toulmin's stages.

Joiner and Jones (2003) stated the inadequacy of time allocated for discussion as a limitation of their study. In that study comparing the impacts of different communication media on argument quality and argumentative reasoning, a pretest and posttest involving an online discussion or a face-to-face discussion was administered. The group involved in the online discussion took part in seminary discussions for approximately 2 weeks, while only one session was held for the face-to-face discussion. Those using the computer-aided environments were given 2 weeks. However, it was mentioned that this time period was insufficient to bring about and notice any development in their skills.

Kuhn, Shaw and Felton (1997) found no development in the argumentation level of students who attended just 1 session, and reported that progress in argumentation quality was achieved only after 5 sessions. Similarly, Anderson and Soden (2001) stated that progress in argumentative reasoning occurred after 10 sessions.

It is thought that a longer "period of time" should be used in order to observe the progress in students' skill of creating an argument. It is predicted that the number of topics covered will increase and students will construct higher quality arguments in accordance with the extended training process.

In Joiner and Jones (2003), higher quality arguments were observed among students in a face-to-face environment compared to the arguments used in online discussions (An online discussion form was used for the online discussion group). It was stated that, as students involved in face-to-face arguments also paid attention to each other's pronunciation and included it in their evaluation and sense-making process, they became more successful. As it is seen, there is greater evaluation of the element in analysis of oral arguments, which creates an environment in which students can express themselves better. Osborne et al. (2004) used video recordings to evaluate the oral arguments made by students. Therefore, a follow-up study is also planned to analyze video recordings and include oral arguments in the evaluation.

Conclusions

In the present study, it was seen that the argumentation skills of students developed their critical thinking skills and skill of constructing an argument. Individuals constructing high quality arguments made use of their critical thinking skills while constructing their own arguments, identifying evidence to support their own claims, and questioning the evidences of the opposing idea. Accordingly, this development in their skill of constructing an argument also contributed to the development of their critical thinking skills. An increase was found in the quality of written arguments formed through pre- and post-test applications. The main reason for this increase was considered to be the activity sheets developed to promote the skill of constructing an argument, which guided participants in the process of constructing an argument.

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Appendixes

Appendix 1

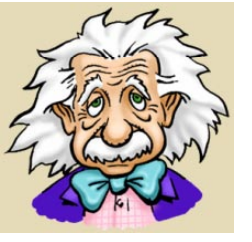
A Sample Activity

Which One Tells The Truth?

Daily person☺

I think we define "work" in physics and daily life in the same way. For instance, I do work when I carry the books on my shoulders to a different place. That is because books weigh down on my shoulders, and I will be tired as I do work.

Scientist☺



I think scientists made a different definition for "Work". For example, I do work when I go to school running. That is because an object must be moved in accordance with the force so as to do work.

1. *Which one told the truth?*
2. *Why did you decide on that?*
3. *Do you agree with the scientific argumentation given by the scientist in the example?*
4. *Why?*
5. *Re-write the above-mentioned argument of daily person with evidences, but it must be persuasive.*

OUR ARGUMENT

Our group supports the argument _____.

We believe in that because: _____

Improved argument of the daily person

I think the everyday person made a _____ explanation because ….

Another reason is that …

The first reason why the argument presented by the everyday person is incorrect is ….

Overall, I think....

Additional Evidence

If one can move an object in the same direction with the force applied, that means that one does work.

The unit of work is N.m.

The hand of a student does work when preparing a composition assignment given by the teacher.

Ayşe does work when she pushes the wall with a great force.

A student does work when taking and replacing books on the shelf.

Exhaustion of a person may explain that he has done work.

If we apply a downward force to an object on the ground, the object moves.

That Ahmet opens the door when the bell rings shows that he does work.

To make the magnitude of work double, either two-fold force must be applied to the object, or the object must be moved double the distance.

Scientists define some concepts differently in physics compared to the definitions used in daily life.

Appendix 2

Rubric Evaluation Concerning Skills of Creating an Argument

SCORE	4 (VERY GOOD)	3 (GOOD)	2 (MEDIUM)	1 (IMPROVABLE)	0 (INADEQUATE)
USE OF THE CLAIM	Able to express opposing claim with at least one **data** and/or **warrant**.	Able to make an opposing claim by preferring the correct claim among those given.	Able to identify the correct claim among several given.	Selected an incorrect claim among several given.	Unable to make any claim; could not make any comment.
USE OF THE DATA	He/she could use more than one strong data (He/she took the data from the case in the example and expressed the relationships between claim and data with warrant.)	He/she could use one strong data.	He/she could use at least one weak data (Weak data: He/she could just describe what he/she understood from the example given as a physical term.)	Incorrect data were used (Incorrect data: He/she could just describe what he/she understood from the example given as a physical term.).	He/she could not use any data, could not make any comment.
USE OF THE WARRANT	He/she could use more than one strong warrant.	He/she could use one strong warrant.	He/she could use at least one weak warrant. (Weak warrant: Justification of the claim with weak data)	He/she used incorrect warrant/s (incorrect warrant: Justification of the claim with incorrect data)	He/she could not use any warrant, could not make any comment.
USE OF THE CONJUNCTION	He/she could explain his/her warrant by using one of the conjunctions "because" and "for".	He/she could use one of the conjunctions "for" or "because" as a bridge between data and claim.	He/she could use "According to this example", "According to Mehmet/Ozgur" to give evidence.	He/she could combine two judgments or claims and data by means of the conjunction "and", and think both of them at the same time.	He/she could not use any conjunction.
USE OF THE ADDITIONAL CONCEPTS	He/she could use at least one evidence. Evidence: It refers to data pertaining to correctness of the warrant. (it can be a formula, personal information or bringing forward a witness... etc.)	He/she could use at least one backing. (Backing: It refers to making different verifications in which one's claim can be valid)	He/she could use at least one qualifier. Qualifier: It refers to expressing under which conditions the expression put forward can be correct (expressing under which conditions the expression put forward cannot be true)	He/she could express the situation in the example given in the question with physical terms. (For example, describing the force applied and move in the example given, reaching the definition of work, the work, force, move against gravity force, etc.)	He/she could not use any additional concept.

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