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Abstract

Recent reform efforts in science education have brought scientific literacy to researchers' attention. Researchers have been searching for new instructional models to engage students' variety of scientific practices to fulfil the requirements of scientific literacy. Argument Driven Inquiry (ADI) is a novel instructional model that integrates the practices of argumentation and inquiry. The aim of the study was to investigate the effect of ADI to preservice science teachers 'metacognitive awareness and scientific writing skills. For this purpose single group pre-posttest design was conducted with 50 pre-service science teachers. It was found that ADI helped to improve pre-service science teachers' meta-cognitive awareness and writing skills. There are some conclusions and implications of the study for researchers and teachers dealing with scientific literacy and laboratory applications in the current study.

Introduction

Helping students develop skills of scientific literacy is the central aim for reform efforts in science education (National Research Council , 1996). Of the numerous definition for scientific literacy found in the literature OECD (2015) defined scientific literacy as "the ability to engage with science-related issues, and with the ideas of science as a reflective citizen". It is clear in this definition that scientific literacy involves not only understanding scientific issues but also having the ability to make science. Duschl, Schweingruber, and Shouse (2007) emphasized that scientifically literate person should know the scientific explanations of the events, solve the problems by applying scientific methods, evaluate scientific explanations and arguments and understand the nature of the scientific knowledge and inquiry. Moreover, developing reading and writing skills to evaluate the scientific claims and using one's own knowledge and reasoning skills to solve daily life problems and decision making process are the common features of scientific literacy definitions found in the literature (Cigdemoglu, Aslan and Cam, 2017).

In order to use one's own knowledge and reasoning skills to daily life situations, developing metacognitive awareness of students is very critical (Hartman, 2001). Metacognition has been defined as cognition about cognition (Flavell 1979). Flavell (1979) emphasized that metacognition refers being aware of one's own cognitive processes and controlling them (Zohar, 2004). Individuals with metacognitive awareness are aware of their own cognitive processes. Metacognition involves two broad categories, namely "metacognitive knowledge" and "metacognitive activities". Metacognitive knowledge and activities, which involve goal setting, planning, and strategy selection and modification (Ohtani & Hisasaka, 2018) are the necessary elements that facilitate to fulfil the requirements of scientific literacy. In the literature there are number of studies showing that metacognitive awareness is a key factor in learning science since it allows individual to regulate their cognitive skills and evaluate task performance effectively (Coutinho, 2007; Dunning, Johnson, Ehrlinger and Kruger, 2003; Winne, 2011).

Scientific writing is the other aspect of scientific literacy. Sampson and Walker (2012) discussed two important reasons for integrating scientific writing to science classes on a regular basis. First of all, students should learn how to share theory, design and results of their investigations in a written text like a scientist. Secondly, "writing can help promote and support metacognition and deeper understanding the content under investigation" (Sampson and Walker, 2012, p.1444). They argued that written texts allows students to analyse, reflect and challenged their thoughts more easily. Although its importance as a critical component of scientific literacy is highly recognize (Eymur, 2018; Pratt & Pratt, 2004; Wallace, Hand, & Prain, 2004), current researches consistently shows that students have few opportunity to write their investigations to share with peers in science classes (Kelly et al., 2008) and as a result they have difficulty in communicating their scientific investigations in written (Kelly & Bazerman, 2003; Kelly & Takao, 2002).

In parallel with the aim of increased scientific literacy, number of instructional models have been proposed to engage students' variety of scientific practices to fulfil the requirements of scientifically literate citizens who have high metacognitive awareness and scientific writing skills. Argument Driven Inquiry (ADI) as a novel instructional model integrate the learning of core ideas with argumentation, inquiry and writing. This model provides opportunities for students to design their own research questions, make scientific arguments, write critical reports and to evaluate them. It also supports the development of students' understanding of core scientific concepts and scientific discourse (Sampson & Walker, 2012).To achieve these goals, ADI includes eight interrelated steps: identification of task, generation and analysis of data, production of a tentative argument, argumentation session, explicit and reflective discussion, creation of written investigation report, double blind peer-review of the reports, and revision of report (Sampson, Carafano, Enderle, Fannin, Grooms, Southerland, Stallworth, & Williams, 2014). Researchers dealing with argumentation in general and ADI specifically hypothesized that these scientific practices improve students' metacognitive awareness (Erduran & Jimenez-Aleixandre, 2007,Demircioglu and Ucar, 2012, Kadayifci and Celik,2016, Sampson and Walker, 2012, Zohar and Dori, 2003), argumentative writing skills (Sampson & Walker, 2012), their ability to construct a scientific argument, their attitudes toward science (Walker, Sampson, Grooms, Anderson, & Zimmerman, 2012), and their understanding of core scientific ideas(Sampson & Walker, 2012) by means of the various activities embedded into it. From this point of view, ADI as including scientific practices and being presented as a new laboratory approach gains importance as a realistic and authentic approach that will play an active role in both writing skills and metacognitive skills of the students (Cetin, Metin & Kaya, 2016).

As Sawada, Piburn, Turley, Falconer, Benford and Bloom, (2000) stated student centered approaches underlie the recent reform efforts. So any instructional approach that engage students with science related real life problems have a potential to increase students' learning (Lesh, Cramer, Doerr, Post ve Zawojewski, 2003). In parallel with this thought it seems reasonable to engage students with the activities embedded in ADI Although there are some studies showing that the ADI facilitates college and high school students' scientific writing skills (Sampson, Enderlee, Grrooms &Witte, 2013; Sampson & Walker, 2012), there is no study investigating the effect of ADI on preservice teachers' metacognitive awareness and writing skills together. Therefore, the main aim of this study is to investigate the effect of ADI on preservice teachers' metacognitive awareness and writing skills.

Research Question

In this study we dealt with how a relatively new laboratory instructional model called ADI effect preservice science teachers' metacognitive awareness and scientific writing skills. Thus two research questions guided this study: Does the Argument Driven Inquiry method facilitate preservice science teachers' (a) metacognitive awareness and (b) scientific writing skills.

Method

Research Design

The study used a single group pre-posttest design since it aimed to investigate metacognitive awareness and writing skills of pre-service science teachers via pre-test and post-test. As Gay & Airasian (2000) explained in this design a treatment is exposed to a single group and pre-test and post-test are applied to group in order to measure the success of the treatment. Although the authors acknowledge the weakness of this design in controlling the factors that threat external and internal validity (Fraenkel & Wallen, 2006), the context of the study and the nature of research question were not necessitate and suitable to use a control group.

Participants

The study was carried out in the course of Laboratory Application in Science in the academic year of 2015-2016 with 50 pre-service teachers comprised the entire class of third grade students in elementary science teacher education program. The study group consists of 16 male and 34 female pre-service teachers aging between 19 to 22. Before the study, participants completed General Chemistry I-II, General Biology I-II, and General Physics I-II laboratories. These pre-service teachers were selected due to their convenient accessibility and proximity to the researchers. All pre-service teachers participated in the intervention as a part of the course curriculum.

Instrument

In order to examine the metacognitive awareness of the pre-service science teachers, Metacognitive Awareness Inventory (MAI) developed by Schraw and Denisson (1994) and adapted to Turkish by Akin, Abaci and Cetin (2007) was used. In the reliability examination of the scale, the reliability coefficient obtained from the original adaptation study by test- retest was 0.95; the reliability obtained by the method of dividing the half was 0.91 and the Cronbach alpha reliability coefficient was found to be 0.95. The translation validity of the scale was found to be 0.89 and the compliance validity was found to be 0.93. In the following table dimensions, the number of items in each dimension and the example items of Metacognitive Awareness Inventory are given.

Table 1. Dimensions and example questions of MAI

Dimension	**Definition of sub-scale**	**Number of Items**	**Example**
Declarative Knowledge	refers to knowing “about” things.	8	I understand my intellectual strengths and weakness.
Procedural Knowledge	refers to knowing “how” to do things.	4	I have a specific purpose for each strategy I use.
Conditional Knowledge	refers to knowing the “why” and “when” aspects of cognition.	5	I use different learning strategies depending on the situation.
Planning	involves the selection of appropriate strategies and the allocation of resources that affect performance	7	I ask myself questions questions about the material before I begin.
Information Management Strategies	skills and strategy sequences used to process information more efficiently .	9	I focus on the meaning and significance of new information.
Monitoring	assessment of one’s learning or strategy use	8	I find myself pausing regularly to check my comprehension.
Debugging Strategies	strategies used to correct comprehension and performance errors	5	I stop and go back over new information that is not clear.
Evaluation	analysis of performance and strategy effectiveness after a learning episode	6	I ask myself if I have a considered all options after I solve a problem.

In order to examine the scientific writing skills of pre-service science teachers, "Scientific Writing Skills Assessment” produced by Sampson and Walker (2012) and translated into Turkish by Cetin, Eymur, Southerland, Walker and Whittington (2018) was employed. The rubric consists of 4 sections. These are: Introduction and The Research Question section, Method section, Argumentation section, and Technical section. Evaluation of the form is done between 0-2 points. "0" means that the anticipated situation is not observed and "2" means that the expected situation is best provided. The highest score that can be gained from the form is 48

The Implementation Process

The study that was conducted to examine the effect of ADI on the level of metacognitive awareness and writing skills of pre-service science teachers lasted 12 weeks. As shown in Table 2, ADI activities were conducted at the initial 9 weeks of 12-week period. Before the implementation started, the group was informed about the steps of ADI and scientific ethics by one of the researchers. Table 2 shows the activities handled during 12 weeks. The laboratory activities which were prepared about density, solubility, durability, enzymes and water quality were prepared for selected objectives from the science curriculum.

Each ADI activities starts with teacher’s distribution of a handout including a guiding research question (Table 3). The handouts were prepared to show how a piece of scientific background information is relevant to research question and a list of available materials that students could use to design their investigation. In order to capture students attention research problems are selected in a way that they were related to students’ daily life and give opportunity for students to discover something (Walker & Sampson, 2013). Then students were assigned to groups to decide and implement a research method to propose a claim which constitute a solution to the research problem. Walker and Sampson (2013) framed this process as guided inquiry since students try to design and implement a method to collect data, decide ways to analyze data and assert an argument that answer the research question.

Table 2. The Implementation Process

Week	Application
1	MAI was applied as a pre-test
2	Giving information about ADI, scientific ethics, scientific research process
3	The activity named “Density” was conducted
4	The activity named “Rate of Solubility “ was conducted
5	The activity named “Endurance” was conducted
6	The activity named “Endurance” was ended
7	The activity named “How do enzymes work?” was conducted
8	The activity named “ How do enzymes work?” was ended
9	The activity named “Quality in Water” was conducted.
10	The activity named “Quality in Water” was proceeded
11	The activity named “Quality in Water” was ended
12	MAI was applied as a post-test

After collecting the data, students analyze and interpret data to produce a tentative argument including an explanation to the guiding research question, evidence to support the explanation and a rationale for the choice of evidences. Then, this argument is transferred on a whiteboard in order to share it with whole class. One of the group member presented their argument to other groups and answered the questions about the conclusion they came up, the processes they used and theoretical foundation of their inquiry. Argumentation session give opportunity for students to present their arguments to entire class and critiques the arguments presented by their peers. Once each group presented their arguments, students individually write an investigation report that organized around three questions: What were you trying to do, and why? What did you do, and why? What is your argument?(Walker, et al, 2012). Students were asked to submit two copies of their report with a nickname for double blind peer review. The instructor distributed two reports written by two different peers and peer review sheets including criteria for evaluating the reports to each student. By this way each student evaluated two reports written by their peers randomly. The activity ended with the revision of the reports by students with respect to peers’ feedback

Table 3. Descriptions of the activities

Name of the activity	Guiding question
Density	What are the identities of unknown matters?
Rate of Solubility	What factors affect the dissolving process?
Endurance	What is the dependence of the strength of a bridge?
How do enzymes work?	What factors affect enzyme activity?
Quality in Water	Investigate the usability of sample which is taken from different water sources through control experimental design.

Data Analysis

The scores obtained from MAI were analyzed by t-tests. When the normality analyses of each sub-dimension of the pre-test and post-test results obtained from the MAI inventory were examined, it was seen that the dimensions other than the conditional knowledge sub-dimension showed normal distribution. The Wilcoxon Marked Rank test was used for the conditional knowledge subscale to examine the relationship between the pre-test and the post-test while the dependent samples t-test was applied for the other dimensions. In order to determine whether there was a significant difference between the scientific writing skills of pre-service science teachers through five weeks ANOVA was conducted. Each participant’s report was scored using a rubric developed by Sampson and Walker (2012) by one of the researchers.

Results

Results of this study are reported in two subsections in a way that each section devoted the one research question. The first section concentrate on the results about pre-service teachers’ metacognitive awareness and the second section concentrate on the results about pre-service teachers’ scientific argumentative writing. To answer each research question related statistical analyses were presented and effect size values were reported to determine whether the difference between the measurements was practically meaningful (Cohen, 1988).

Concerning the Metacognitive Awareness Inventory

In Table 4 dependent sample t test results for metacognitive awareness level of pre-service teachers were given.

Table 3. Dependent sample t test for metacognitive awareness level of pre-service teachers

Factors	Measurement	N	$\bar{X}$	SD	df	t	p	η^2
Declarative Knowledge	Pre-test	50	30.70	3.87	49	-2.74	.008	.13
	Post _test	50	32.12	3.90	49			
Procedural Knowledge	Pre-test	50	13.88	2.60	49	-4.00	.001	.24
	Post _test	50	15.30	2.31	49			
Planning	Pre-test	50	25.20	4.31	49	-2.25	.029	.09
	Post _test	50	26.64	3.95	49			
Monitoring	Pre-test	50	28.76	4.52	49	-2.09	.042	.08
	Post _test	50	28.90	4.21	49			
Evaluation	Pre-test	50	21.72	3.52	49	-2.47	.017	.11
	Post _test	50	22.88	3.31	49			
Debugging	Pre-test	50	18.82	3.21	49	-2.31	.025	.09
	Post _test	50	19.82	4.21	49			
Information Management Strategies	Pre-test	50	34.12	4.21	49	-3.42	.001	.19
	Post _test	50	35.76	4.02	49			

For declarative knowledge dimension Table 4 shows pre-test ($\bar{X}$=30.70) and post-test scores ($\bar{X}$=32.12) of the pre-service teachers, and it reveals a significant difference t(49)=-2.74, p<.05, η^2=.13. The participants' score from this dimension is thought to be high both in pre and post-tests when we considered that the maximum score that can be taken from these dimension is 40. In procedural knowledge dimension, it is seen that there is a significant difference (t (49) = - 4.00, p <. 05, η2 = .24) between pre-test scores ($\bar{X}$ =13.88) and post-test scores ($\bar{X}$ =15.30). We can say that the instruction may cause 1.42 point increase in participants' scores in this dimension. In relation to the planning dimension, according to the result of t-test there is a significant difference (t (49) =-2.25, p<. 05, η2=. 09) between pre-test scores ($\bar{X}$ = 25.20) and post-test scores ($\bar{X}$ = 26.64). Although the instruction cannot close participants' score to the maximum of 35 that can be taken from this dimension, the difference was found significant. The similar results can be seen for monitoring, evaluation and debugging dimensions. In the monitoring dimension, t-test shows a significant difference (t (49) =-2.09, p<. 05) between pre-test scores ($\bar{X}$ = 28.76) and post-test scores ($\bar{X}$ = 28.90). For the evaluation dimension, according to t-test results there is a significant difference (t (49) =-2.47, p<. 05, η2=. 11) between pre-test scores ($\bar{X}$ = 21.72) and post-test scores ($\bar{X}$ = 22.88). As for the debugging dimension, it is seen from the t-test results that there is a significant difference (t (49)=-2.31, p<. 05, η2=. 09) between pre-test scores ($\bar{X}$ = 18.82) and post-test scores ($\bar{X}$ =19.82). At the information management strategies dimension, according to the result of t test, it is seen that there is a significant difference (t(49)=-3.42, p<.05, η2=.19) between pre-test scores ($\bar{X}$ = 34.12) and post-test scores ($\bar{X}$ =35.76). When we considered that the maximum score that can be taken from these dimension is 45 the participants' score from this dimension is thought to be high both in pre and post-tests.

When the findings given in Table 5 regarding the conditional knowledge sub-dimension are examined, it is shown that there is a significant difference between pre and post-implementation scores of the pre-service teachers: Z = 2.21, p <. 05, η2 = .09. When the rank averages and sums of difference scores are taken into consideration, it is seen that this difference is favoured by positive rankings, that is, the post-test score. When Table 4 and Table 5 were examined, it was found that ADI helped to improve science teachers' of meta-cognitive awareness. It is seen that ADI applications have a high influence on information management strategies, procedural knowledge, and declarative knowledge when the effect size values are examined. Finally, effect sizes for conditional knowledge, debugging, evaluation, monitoring and planning dimensions were found to be moderate.

Table 4. Wilcoxon signed rank test results for the conditional knowledge sub-dimension

Sub-dimension	Pre-test-Post-test	n	Rank Average	Rank Total	z	p	η^2
Conditional Knowledge	Negative Rank	16	17.25	276.0	-2.21	.027	.09
	Positive Rank	26	24.25	627.0			
	Equal	8	-	-			

Concerning the Writing Skills

The scores obtained from the reports written by the pre-service teachers for 5 activities belonging to scientific writing skills were grouped and analysed. ANOVA was used for repeated measures to investigate whether the mean scores of the measurement sets differed significantly

Table 5. ANOVA results for repeated measures of weekly reports

The source of variance	Total of squares	df	Average of squares	F	p	Significant difference
Between subjects measurement	4202.884	49	85.773			
	7755.384	4	1938.46	179.437	.001	2-1,3-2, 4-3, 5-4
Debugging Total	2117.816	49	10.805			

1: Week 1 report evaluation 2: Week 2 report evaluation 3: Week 3 report evaluation 4: Week 4 report evaluation 5: Week 5 report evaluation

As a result of the analysis on the mean scores of scientific writing skills, there is a significant change occurred in the students' performance (4.49) = 179.431, p <. 01, $\eta2 = .29$. In the Bonferroni test conducted, it was seen that there is a significant change occurred in the pre-service teachers' writing performance on the tests 1 and 2; tests 2 and 3; tests 3 and 4; tests 4 and 5. Table 7 shows mean score of students obtained from the reports written for five investigations:

Table 7. Descriptive statistics of score obtained from the five reports

Reports	N	$\overline{X}$	SD
1	50	28.3	6.7
2	50	33.7	5.4
3	50	38.1	4.6
4	50	41.3	4.3
5	50	45.2	3.7

Discussion and Conclusion

This study concentrated on the effectiveness of the new laboratory instructional model that support both students' understanding of scientific discourse and their understanding of core scientific concepts (Cetin et al., 2018) on preservice science teachers' metacognitive awareness and writing skills. The results of the data analyses revealed that this new instructional model named ADI appeared to enhance preservice science teachers' metacognitive awareness and writing skills.

According to the findings, there was a significant difference in favour of the post-test scores of pre-service teachers in the declarative knowledge subscale of the MAI. Moreover, in the declarative knowledge dimension, it is seen that the value of the effect size is high. It is thought that ADI significantly improves the level of the declarative knowledge of pre-service teachers and increases their awareness. Declarative knowledge refers to the knowledge that whether one can solve the problem situation that he/she is facing or can perform a task (Yıldız et al., 2009). It is considered that the task and quiding question given to the pre-service teachers in the first step of the ADI has increased the declarative knowledge awareness of the pre-service teachers. Because, at this stage, pre- service teachers are experiencing intellectual processes about how to solve the problem or how to fulfil the task in relation to the problem they encounter. Hoffstein and Kipnis (2008) reported that inquiry based activities in which students propose, figure out and discuss questions with peers to be researched have a potential to develop declarative knowledge of them. In this respect, identification the task and the guiding question step of ADI is thought to improve declarative knowledge of pre-service teachers by giving opportunity for them to face them to a problem situation related to a scientific topic under investigation.

When the procedural knowledge sub-dimension of the MAI was examined, significant difference was found in favor of the post-test. Procedural knowledge is one’s own information about how one will apply learning processes or strategies (Schraw & Denisson, 1994). In the second step of ADI, students need to carefully consider how to configure the process to solve the problem situation and decide which method is the most suitable one for probing solution. In this step, before collecting any data students made decisions about data collection method which make them mentally active which may increase the awareness of procedural knowledge. The large effect size obtained for this dimension in this research showed that the improvement in procedural knowledge is high. Tucel, Cakiroglu and Oztekin (2016) study of Science Writing Heuristic on the eighth grade students has revealed that there is no significant difference in the procedural knowledge of students before and after the implementation. This contradiction between studies is thought to be due to the age level between the sample groups. Pre-service teachers are mature enough to develop learning strategies consciously or unconsciously while at the bachelor level, and may have increased procedural knowledge awareness by thinking about strategies that they have learned previously and applying them throughout practice.

In terms of conditional knowledge, significant difference was found in favor of the post-test. It is thought that the awareness of conditional knowledge has increased when the pre-service teachers collect and analyse data in the second and third step of ADI. Conditional knowledge implies that a person knows which method should be used in a specific case and how to use this method properly. The individual is able to employ both declarative knowledge and procedural knowledge for the problem situation he / she is experiencing. In this context, as pre-service teachers gather data and analyse this data, they coordinated and employ both procedural and declarative knowledge. The effect size of situational knowledge has been revealed to be moderate. Although the effect sizes of declarative and procedural knowledge is high, that the effect size of the situational knowledge is moderate which is thought to result from the complexity of the relationship between these dimensions. Similarly Schraw and Moshman (1995) stated that situational knowledge might develop more slowly than other dimensions for this reason.

There was a significant difference in the pre-test and post-test scores of the pre-service teachers in favour of the post-test in terms of information management strategies. Managing information involves organizing, refining, and summarizing information in order to use what the individual learns more efficiently. In the argumentation and report writing steps of ADI, pre-service teachers are supposed to present their knowledge claim, data gathered and their justification which involves processes of organizing and summarizing the information. Moreover, peer review process of ADI forces per-service teachers to write convincing, detailed and organized reports to persuade peers about the accuracy and appropriateness of argument developed. To write such an explanatory and holistic report demands to utilize information management strategies. This result is parallel with the results of Tucel et al.(2016) who reported the largest effect size coefficient in information management strategies.

When the planning dimension is examined, a significant difference was found in favor of the post test. Planning involves planning, using resources and time appropriately in order to achieve the result by thinking about what the person will do for the problem situation they are facing. It is thought that all steps of the implementation may influence the planning dimension of pre-service teachers. The nature of ADI activities from beginning to end should be carried out within a certain plan and the research should be completed within the determined period. The works of Tucel et al. (2016) and Ulu (2011) are in accordance with this research at this dimension. Ulu (2011) stated that in his study where students experienced extensive scientific writing activities showed a meaningful development in planning dimension.

There was a significant difference in the pre-test and post-test scores of the pre-service teachers in the monitoring dimension in favor of the post-test scores. Monitoring includes assessing one's own performance, estimating future practices, assessing the efficiency of the method used, and identifying the mistakes s/he makes in the process. Considering the studies conducted which focus on argumentation and writing in the field writing (Ulu, 2011; Tucel et.al., 2016), it is seen that there is no significant development at this dimension. Unlike the method used in these studies, ADI activities includes reflective argumentation and structured peer review processes which are thought to have an impact on monitoring strategies. These processes provide pre-service teachers to notice the strong and week points of their investigations by comparing their work with the investigations of peers.

As a result of the analysis made to compare the pre-test and post-test scores in the evaluation dimension, a significant difference was found in favor of the post-test. Evaluation is the assessment of an individual’s own learning products and the process of regulation. In the study conducted, the effect size of the evaluation dimension was moderate. Keys (2000) stated that writing inquiry based laboratory reports, where students propose a claim that can be the answer of guiding research question, explain their methods used to investigate research question in detail, and evaluate the process by discussing the appropriateness of this method had an impact on the evaluation strategies of metacognitive awareness. It is clear that ADI activities gave opportunity to pre-service teachers to experience all these processes. Cetin, Eymur, Southerland, Walker and Whittington (2018) echoed the similar results that ADI facilitates students’ engagements of various epistemic practices of science.

In the debugging dimension a significant difference was found in the pre-test and post-test scores of the pre-service teachers in favor of the post-test. The level of debugging includes the person's ability to anticipate problems, correct them, and accomplish future performance by refining these problems. Ehrlinger (2008) noted that the individual with low metacognitive skills performs low level in detecting their cognitive errors. Peer review and report writing steps of ADI applications are the steps in which the most intensive processes in error detection, elimination and correction of errors are take place. In ADI activities, the individual has an active process for finding, sorting and correcting mistakes both for his / her own work and also the peers’ works.

When the effect sizes obtained from each dimension of metacognive awareness inventory were examined, it was seen that they were high for information management strategies, procedural knowledge and declarative knowledge. The effect sizes for conditional knowledge, debugging, evaluation, monitoring and planning dimensions were found to be moderate. From these results, it can be said that ADI method has improved the scores obtained from all dimensions of metacognitive awareness. Literature on metacognitive awareness is consistently emphasized that to structure metacognitive skills in the course is the most effective strategy to improve metacognitive abilities of students (Özsoy, 2008, Zohar, 2004). The nature of ADI activities helps students to use and develop their metacognitive skills which may be the cause of their high scores in all dimension of metacognitive awareness inventory.

The results of the analysis of students’ reports suggest that ADI had a positive impact on pre-service teachers’ scientific writing skills. This result is consistent with some previous studies that report the positive impact of argument driven inquiry on students’ writing skills (e.g. Cetin et al., 2018; Sampson & Walker, 2012). This positive outcome can be attributed to practices inherited in the ADI activities. More specifically, Cetin et.al. (2018) suggested that three components of ADI are particularly influential in developing students’ scientific writing skill which has a central role in their science proficiency. These components are peer review, feedback received from peers and collaborative argumentation which help students to think about the elements of valid argument, realize strong and week points of their arguments and produce to learn strong arguments. When the definition and aims of science literacy is considered within the frame of contemporary science teaching, it is thought that activities including such scientific writing processes are of great importance in terms of science education.

Limitations and Implications

There are certain inevitable limitations of the present study. First of all, the generalizability of the findings is limited because of the small sample size. Secondly, both the writing skills and metacognitive awareness need longer times to develop duration of the study is another limitation. Lastly, since the study was conducted with only one group conducting the study with more powerful experimental designs are recommended. Considering these limitations in mind this study have some implication for the role of argumentation and inquiry in science laboratories. Future studies aiming to create effective learning environments for students will benefit the results of this study. Moreover qualitative studies can be conducted to search the reasons behind the increase in students’ metacognitive awareness and writing skills.

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