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# Effects of Science Journaling on Elementary Students' Affective Characteristics in Korea

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**Abstract:** This study investigated how keeping a journal related to issues and concepts in science influences sixth grade students' affective characteristics, including cognition, interest, and attitude towards science. The development of these characteristics is related to students' attitudes and interests in learning. Previous studies have primarily focused on the affective characteristics of gifted students, while only a few have focused on elementary students in public schools. We asked 34 grade six students in Korean public schools to keep a journal related to science and technology three times a week for 12 weeks (September–November 2018). The results show students' perspectives on writing science journals from data, including questionnaires, interviews, and surveys. The results also suggest that keeping a science journal develops students' affective characteristics related to science. Our findings will contribute to the development of better pedagogies for sustainability and resources for teaching science among elementary students.

**Keywords:** affective characteristics; attitudes; cognition; elementary science education; science journal interests

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**Citation:** Jeong, Y.; Kim, H.; Lee, C. Effects of Science Journaling on Elementary Students' Affective Characteristics in Korea. *Sustainability* **2021**, *13*, 9691. https://doi.org/10.3390/su13179691

Academic Editor: Marc A. Rosen

Received: 6 July 2021
Accepted: 19 August 2021
Published: 29 August 2021



## 1. Introduction

Following the significant emphasis on science education and the role it plays in technological advancement and globalization, many initiatives have aimed at motivating students to pursue careers in science and technology. Many of these initiatives focus on students' academic performance and achievement. The promotion of students' skills and knowledge within science-related affective domains has become essential for 21st-century citizens, making it an educational goal worldwide [1–3].

The term "affective domains" in the context of this study encompasses cognition, interests, and attitudes towards science [1,4]. In this study, we investigated the effects of using science journal writing as a tool to influence elementary students' affective domains in learning science. The benefits of writing about science have been extensively researched over the last three decades [5,6]. In Korea, a number of studies have investigated the effects of science writing [7–9]; however, most have focused on gifted students and/or intermediate and high school students. Studies that focus on elementary students are lacking, despite elementary science setting the foundation for subsequent science learning and the elementary years being the point at which students develop key intellectual skills, attitudes, and habits [10]. Therefore, in this study, we explored the effects of science writing and science journal writing on Korean elementary students' science-related affective characteristics.

## 2. Theoretical Background

### 2.1. Affective Characteristics

The term affective characteristics stem from Bloom's widely acknowledged and re searched taxonomy that categorizes learning levels into three different domains: Cognitive, psychomotor, and affective [11–14]. The affective domain describes the emotional processes of learning, focusing on feelings, values, motivations, attitudes, and dispositions [11].

Anderson and Bourke [15] linked these affective domains to human characteristics, explaining that cognitive characteristics represent "typical ways of thinking"; psychomotor characteristics are "typical ways of acting"; and affective characteristics are "typical ways of feeling" (p. 4). They emphasized the importance of the word "typical" in defining affective characteristics as humans are not computers—their feelings are subject to a variety of internal and external factors. Therefore, when assessing affective characteristics, we followed the two criteria reported in Anderson and Bourke [15]: (1) They must involve the feelings or emotions of the subject and (2) they must be typical feelings or emotions of the person. Therefore, when assessing affective characteristics, the intensity, direction, and target of a person's feelings should be considered [16]. Affective characteristics can be both the outcome and consequence of learning; they usher the student into subsequent lessons that influence learning. McLeod [17] emphasized the importance of researching affective domains, stating 'If research on learning and instruction is to maximize its impact on students and teachers, affective issues must occupy a relatively more central position in the mind of researchers' (p. 575). In the field of science education, science writing has gained recognition for its impact on enhancing students' learning and facilitating various science processes and skills related to affective domains.

### *2.2. Science Writing*

Science writing refers to students' free expression of their understanding of scientific facts, concepts, principles, laws, theories, and hypotheses [18]. The positive effects of science writing have been discussed in previous studies [1,5,6,19]. For example, Glynn and Muth [19] understood science writing as a "conceptual tool for helping students analyze, interpret, and communicate scientific ideas" (p. 1058), through which students can discover new ideas and clarify their thinking around the topics of science. In this manner, science writing can help engage students in complex reasoning and problem-solving processes.

Various studies, including Keys [20], have investigated different techniques to enhance the effect of learning science through science writing. The results suggest that students should use scientific reasoning to solve a problem when writing about issues and phenomena related to scientific concepts; reasoning can further expand their scientific thinking processes and interest and, in turn, have a positive effect on their writing activity. Writing is a required learning tool for communicating and constructing knowledge in the field of science [21]. Learners have metacognitive structures, such that employing different types of writing styles, subjects, and methods can improve learning and lead learners to higher levels of thinking [1,19]. Recognizing the value of writing as a learning tool, many Korean schools promote the use of science writing [22]. To date, writing a science journal is the most ongoing scientific writing activity in elementary schools in Korea.

### *2.3. Science Journals*

Writing a journal involves recording thoughts and emotions about and reflecting on a topic according to purpose and need. Writing a science journal on a regular basis encourages students to express their ideas freely, improves understanding of the natural phenomenon, and improves general writing skills [7,23]. Writing science journals also offers students the chance to utilize observations, make judgments, frankly express emotions and thoughts, and explore different vocabularies and genres of writing to discuss scientific topics.

Moreover, keeping a science journal allows students to draw from their daily experiences of scientific concepts and further question issues and phenomena related to science. Science learning becomes 'constructive rather than rote' [19]. Peyton (1993) [24] identified the benefits of keeping a science journal as offering a chance for students to explore and expand new scientific concepts based on prior understanding.

Writing a science journal also helps students to better understand scientific concepts by allowing them to link their own daily experiences with scientific phenomena [1,23].

Writing a science journal promotes inquiry-based learning. Park and Kim [9] stated that students often experience inquiry subjects in their daily lives, such that keeping a journal helps students express their thoughts on various topics related to science and technology, which may or may not be related to the concepts they are learning in science class. Moreover, by facilitating students' inquiries about science in their daily life, writing science journals enhances other abilities related to scientific inquiry, such as observation, classification, measurement, inference, expectation, data conversion, data interpretation, setting up hypotheses, and identifying control variables [1,18,20]. By offering students the chance to think and reflect upon various scientific phenomena in a manner that is different from traditional knowledge acquisition, writing science journals links students' daily experience to scientific phenomena, which, in turn, influences students' affective domains in science. Writing science journals increases students' interest in learning science and science-related curiosity in their daily lives [1,9,22].

## 3. Materials and Methods

### *3.1. Participants*

Participants in this study were 34 sixth-grade students from an elementary school located in Gyeonggi-do, Korea. All students had a relatively similar socio-economic status. Participation was voluntary and students could withdraw from the study at any time. The data collected (including journals, interviews, questionnaires, and surveys) were not graded.

### *3.2. Data Collection*

In August 2018, prior to writing journals, students were invited to answer two different questionnaires: A Group Assessment of Logical Thinking (GALT) and an evaluation framework of science-related affective domains [25]. The GALT is a pencil and paper test first developed by Roadrangka et al. [26] to measure students' logical thinking ability and many versions have since been published. We adopted the Yang and Kang [27] version, which is modified from the original to include questions specifically focused on testing logical thinking ability and affective aspects related to science. The reliability of the Yang and Kang [27] version based on Cronbach's $\alpha$ was 0.76. In addition, we followed the Chung and Ahn [25] categories of affective domain, which reflect the Korean science curriculum. In particular, Chung and Ahn [25] developed 48 questions on affective domains related to Korean education. These 48 items were classified into three different domains (cognition, attitudes, and interests) that were then piloted and tested. The Cronbach $\alpha$ coefficient of the evaluation framework ranged from 0.83 to 0.86, which suggests that the assessment of science-related affective domains is reliable.

Before and after the science journal writing activity, the GALT was distributed to all participating students. In addition, according to the Group Assessment of Logical Thinking (GALT) test, logical thinking stages were divided into the concrete operational stage, the transition period, and the formal operation stage developed by Roadrangka et al. [26]. Based on the results of the logical reasoning ability test, students were divided into three groups: A high-level group (six students), a middle-level group (10 students), and a low-level group (18 students). To measure students' science-related affective domains in science education before and after the study, a science-related affective domains questionnaire was distributed among participating students (Chung and Ahn, [25].)

During the last week of August 2018, we introduced participating students to the concepts of writing science journals, along with different examples in the presence of their classroom teacher. Students were invited to write about any science topic in their journal; they were encouraged to write in complete sentences (because this helps elementary students develop better writing skills) and to include drawings or poems. Students were asked to make entries in their science journals three times a week (although once or twice a week was accepted) for 12 weeks from September to November.

In addition to making journal entries and taking the GALT and pre-activity tests, all participating students completed the post-activity survey. The post-activity survey was based on the Chung and Ahn [25] questionnaire and modified by two science education experts to better fit the context of our study. This modified post-activity survey consisted of four open-ended questions:

(1) Do you think that your perception (cognition) of science changed after keeping a science journal?
(2) Do you feel more interested in science after keeping a science journal?
(3) Do you think that writing a science journal changed your attitude towards science?
(4) After writing a science journal, has your general attitude towards your daily life changed?

According to the one-group pre- and post-test design using a non-equivalent dependent variable by quasi-experiment, we designed the experiment and conducted the experiment process for validity. In addition, it increased the reliability of research results through the triangulation method by qualitative and quantitative research methods [28]. Individual interviews were conducted after the post-activity survey. Eight students were selected for the interview through stratified cluster random sampling based on their logical thinking ability determined by the GALT results. According to the GALT results, three groups were divided into the concrete operational stage (low group), the transition period stage (middle group), and the formal operation stage (high group). Participants A, B, and C were included in the concrete operational stage (low group), D, E, and F in the concrete operational stage (low group), and G and H in the formal operation stage (high group). Each interview took 45 min; the data were transcribed and self-checked by students along with their parents.

### *3.3. Data Analysis*

Data from the post-activity survey and interviews were analyzed based on students' level of logical thinking ability determined by the GALT results (e.g., high: Formal operational stage; middle: Transitional period; and low: Concrete operational stage groups of logical thinking ability). Moreover, all questions from the science-related affective characteristics and post-activity survey were reclassified into our three-research study focuses—change in the cognition of science, interest in science, and attitude towards science.

## **4. Results**

### *4.1. Effects of Science Journals on Students' Cognition of Science*

#### 4.1.1. Pre- and Post-Activity Affective Domain Questionnaires

Questions related to cognition of science from the science-related affective domains questionnaire [4] were grouped for analysis. The average value of students' cognition of science before keeping a science journal was 40.76 (SD = 4.687), rising to 41.65 (SD = 5.162) after the activity, indicating an improvement in students' cognition of science (N = 34). The $p$-value (0.011) suggests that the results are significant ($p < 0.05$).

Table 1 lists how writing a science journal affects the sub-factors of cognition. In general, writing a science journal had a positive impact on every sub-factor of students' cognition of science. However, the p-values of these sub-factors, including cognition of science education, careers in the field of science, and STS (science, technology, and society), were higher than 0.05, which indicates that they were not statistically significant. Therefore, examining the results from additional post-activity surveys was required to determine the ways in which writing a science journal affects students' perceptions about science in a more detailed manner.

**Table 1.** Sub-factors of cognition (N = 34).

| Sub Factor | Division | Average | Standard Deviation | Standard Error | *t* | *p* |
|---|---|---|---|---|---|---|
| Cognition of science | Pre-test | 9.89 | 1.597 | 0.319 | 2.246 | 0.032 * |
| | Post-test | 10.51 | 1.583 | 0.386 | | |
| Cognition of science learning and teaching | Pre-test | 10.56 | 1.645 | 0.214 | 1.983 | 0.071 |
| | Post-test | 12.19 | 1.675 | 0.292 | | |
| Cognition of science related careers | Pre-test | 9.25 | 1.589 | 0.268 | 0.385 | 0.539 |
| | Post-test | 9.28 | 1.921 | 0.383 | | |
| Cognition of importance related to STS [a] problems | Pre-test | 9.81 | 1.625 | 0.383 | 1.899 | 0.071 |
| | Post-test | 10.12 | 1.959 | 0.369 | | |

* $p < 0.05$, [a] STS: Science, technology, and society.

#### 4.1.2. Post-Activity Survey

Table 2 lists an analysis of the first question in students' survey questions (Do you think that your perception (cognition) of science changed after keeping a science journal?). Based on their logical thinking ability, we re-categorized students' answers from the survey.

**Table 2.** Post-questionnaire perception of science (N = 34).

| | Changed | | | Unchanged |
|---|---|---|---|---|
| Group | Changed a Lot | Changed a Little | Total (%) | Total (%) |
| All | 3 | 12 | 15 (44) | 19 (56) |
| High | 0 | 3 | 3 (8.8) | 3 (8.9) |
| Middle | 2 | 3 | 5 (14.7) | 5 (14.8) |
| Low | 1 | 6 | 7 (20.5) | 11 (32.3) |

From Table 2, writing a science journal helped change their perception of science. Some perceptions that students held prior to writing a science journal were as follows:

- Science is a difficult subject.
- Science is what scientists do, so it is none of my business.
- Only smart people can do science.

However, after keeping science journals, students found science to be more relevant to their lives and revised their view of science. Meanwhile, 56% of participating students stated that keeping a science journal did not affect or change their perception of science. After writing science journals, these students expressed the following changes in their perception of science:

- Science is present in our daily lives.
- Scientific principles are applicable in many instances in our lives.
- Every convenience in our lives is attributable to scientific principles.

This may be because many students from the high-level logical thinking ability group already had positive perceptions of science, as can be inferred from comments such as "I was interested in science or learning science before the journal writing activity and I have maintained my interest." However, overall, students stated that writing a science journal helped increase their positive perceptions of science (whether or not they had positive views on science prior to keeping a journal).

#### 4.1.3. Interviews

To further investigate students' cognition of science in relation to writing science journals, we asked students whether keeping a science journal helped them to think about science more than before. Students were asked to answer "yes" or "no" and then elaborate on their answers. Below are some of the responses from students who thought that writing a science journal helped them think more frequently about scientific issues and concepts:

> Student B: I think of science only during science class, but now I always think of science.

> Student E: I like the fact that writing a journal made me feel more intimate with science. I used to think that science is what is in the science textbook, but now I know that science can be hidden in my life.

> Student H: Usually, I think a lot about what science is whenever I take the science experiment class and gifted education. I think that writing a science journal provides an opportunity for me to think about science.

Based on the results of the individual interviews, writing a science journal helped students from the high-, middle-, and low-level groups of logical thinking ability to feel more familiar and intimate with science and to recognize the relevance of science in their daily lives.

To determine whether there were any changes in students' perception of science class, we posed the following question to participating students: "Do you think that keeping a science diary changes your thoughts on science class?" In response, student H from the high-level group and student E from the middle-level group explained that they maintained their science journals to solve problems posed in their science class or to review what they learned in class.

> Student H: I used to be into science and did not find taking a science class burdensome. My thoughts about science class have changed.

> Student E: I liked making searches that were relevant to science and keeping a science diary through science class.

When asked if writing journals helped them change their perception about scientists, two students answered that it did not help them:

> Student G: When I think of scientists, Einstein comes to mind. I also want to be a great scientist like Einstein. Not because of the science diary, I've always wanted to be a scientist.

> Student D: Science is very relevant to our lives, scientists, too. This thought did not change before and after keeping a science diary.

Most high-level logical ability students said that they had a positive view of scientists (e.g., student G). They thought that science helps humanity in general, but scientists normally perform difficult tasks; these perceptions were held by most of the students and did not change. However, students from the middle- and low-level logical thinking ability groups showed changes in their perception of scientists, as described below:

> Student F: I thought that scientists are great, without question. Of course, it didn't change, but something is different: even scientists start from thinking about small things and observing them. I felt like I became a real scientist.

> Student B: I've been looking around more since I started keeping a science diary. I've always thought that scientists would do that. So now, I think that scientists are like me.

Students in the middle- and low-level groups who changed their opinions of scientists now thought that the work of scientists involves what happens in their daily lives. These students felt like they were being scientists whenever they experienced the joy of finding a scientific problem in their daily lives. These students also mentioned that they started to think more critically about facts and ideas and observed their surroundings more critically.

Lastly, we asked students if writing science journals changed any of their perceptions towards science and their society. Many students, including E and F, responded affirmatively:

> Student E: I think our lives have become more convenient because of scientific developments.
>
> Student F: I'm not particularly interested in science, but while I was keeping a science diary, I was thinking that thanks to science, we can live comfortably.

These students thought that the development of science is directly linked to convenience in our lives, as well as advancements in technology and society. Additionally, some students thought that current developments in technology were attributable to scientists and inventors and wrote in their science journals about inventions.

## *4.2. Effects of Science Journal Writing on Interest in Science*

### 4.2.1. Pre- and Post-Tests in Terms of Interest in Science

Table 3 lists the results from the pre- and post-tests from the science-related affective domains questionnaires. From Table 3, the 'interests in science' affective domains averaged 45.65 (SD = 6.956) before keeping a science journal, increasing to 78.12 (SD = 7.862) after keeping a science journal. Therefore, in general, there were some changes in students' interests in science.

**Table 3.** Differences in interest in science (N = 34).

| Division | Average | Standard Deviation | Standard Error | *t* | *p* |
|---|---|---|---|---|---|
| Pre-test | 45.65 | 6.956 | 1.137 | 2.578 | 0.001 * |
| Post-test | 78.12 | 7.862 | 1.367 | | |

* $p < 0.05$.

Table 4 lists how the science journal specifically affected each sub-factor of interest in science. With regards to 'interest in science' and 'interest in science activity,' the $p$-values below 0.05 suggest that the results are statistically significant. However, categories including 'interest in science learning,' 'interest in science-related careers,' and 'anxiety towards science' are not significant ($p > 0.05$). Therefore, the results from the post-activity survey and interviews were triangulated to reveal if writing a journal helps students to develop an interest in science.

**Table 4.** Pre- and post-test results by sub-factor of interest in science (N = 34).

| Sub-Factor | Division | Average | Standard Deviation | Standard Error | *t* | *p* |
|---|---|---|---|---|---|---|
| Interest in science | Pre-test | 9.27 | 1.818 | 0.332 | 2.463 | 0.020 * |
| | Post-test | 9.97 | 2.414 | 0.441 | | |
| Interest in science learning | Pre-test | 8.90 | 2.150 | 0.386 | 1.827 | 0.078 |
| | Post-test | 9.26 | 1.879 | 0.338 | | |
| Interest in science activities | Pre-test | 8.71 | 2.254 | 0.405 | 3.133 | 0.004 |
| | Post-test | 9.74 | 2.175 | 0.391 | | |
| Interest in careers in the field of science | Pre-test | 8.48 | 2.204 | 0.396 | 1.150 | 0.259 |
| | Post-test | 8.87 | 2.291 | 0.412 | | |
| Anxiety towards science | Pre-test | 11.13 | 1.979 | 0.355 | 1.545 | 0.133 |
| | Post-test | 11.39 | 1.927 | 0.341 | | |

* $p < 0.05$.

### 4.2.2. Post-Activity Surveys

We included the following question in the post-activity survey: Do you feel more interested in science after keeping a science journal? Students from different logical thinking ability groups showed different patterns in response to this question (Table 5).

Of the students, 47%, regardless of logical thinking ability level, answered that writing a science journal did not change their interest in science, for example:

- It is boring to write a science journal with a sense of duty and I don't have any particular interest in science
- I used to like science and I can't say that writing a science journal helped increase my interest in science.

**Table 5.** Post-questionnaire interest in science (N = 34).

| | | Changed | | Unchanged |
|---|---|---|---|---|
| **Group** | **Changed a Lot** | **Changed a Little** | **Total (%)** | **Total (%)** |
| All | 7 | 11 | 18 (53) | 16 (47) |
| High | 1 | 2 | 3 (8.9) | 3 (8.8) |
| Middle | 3 | 4 | 7 (20.6) | 3 (8.8) |
| Low | 3 | 5 | 8 (23.5) | 10 (29.4) |

As revealed in the excerpts above, some students were interested in science prior to the study and writing a science journal did not increase their interest in science. Yet, 53% of all students stated that writing a science journal changed their interest in science. For example, writing a science journal helps in organizing ideas and it is fun to write journals after the lab/experiment during science class.

- I became more interested in science because I am always trying to find a topic for my journals.
- When I keep a diary, I find out about scientific phenomena and it increases my interest in science.

These comments indicate that writing science journals provided opportunities for students to think beyond their usual concerns, which, in turn, enhanced students' general interest in science.

4.2.3. Interviews

Students' responses to the question 'Did keeping a science diary change your interest in science?' were varied (e.g., from 'It was helpful' to 'It was not helpful') in the high-level logical thinking ability group, with no significant increase in interest after writing science journals, as revealed by a comment from student H.

> Student H: I have always had an interest in science and still have an interest after keeping a science diary. I felt like I got familiar with science through the science diary. I'm not sure if this says that I became more interested in science.

Students from the high-ability group had been interested in science since before writing the journal; to some extent, writing science journals gave them a sense of familiarity with science, which helped slightly increase their interest in science. We also asked them whether they thought they had become more interested in science after writing a science journal. Example responses included:

> Student A: I began to like science. I think it is because I forced myself to have an interest in science to write the science diary.

> Student B: I read books related to science and I tried to find scientific principles in books with my parents. And this made me more interested in science.

In general, students from the middle-level logical thinking ability group responded that writing science journals increased their interest in science. In contrast, for students in the low-level group (represented by student B), who wrote the diary with the help of parents, writing the science journal offered them an opportunity to understand new scientific principles both in theory and in their daily lives, which enhanced their interest in science.

When asked the question "Did keeping a science journal change your interest in science activity?", students either answered 'yes' or 'no.' Examples of negating responses are as follows:

> Student G: I actually learn principles and do many different experiments in my gifted science class. I have had fun with the science activity before and after writingscience journals.

> Student H: Nothing changed much. I liked science experiments and it was really fun before.

It is possible that students in the high-level group of logical thinking ability, such as student G, had participated in many science activities in their gifted classes and at home. Thus, maintaining a science journal did not initiate the development of an interest in science. However, many students from middle- and low-level groups thought that writing science journals changed their interest in science.

### *4.3. Effects of Writing a Science Journal on Attitudes Towards Science*

#### 4.3.1. Pre- and Post-Test Analysis in Terms of Attitude Towards Science

Questions related to cognition of science from the science-related affective domains questionnaire [4] were grouped for analysis. The average score on items related to attitudes from science affective domains before keeping a science journal was 65.61 (SD = 8.926), rising to 68.39 (SD = 7.981) after keeping a science journal, indicating an improvement in students' attitudes towards science (N = 34). The $p$-value (0.003) suggests that the results are significant ($p < 0.05$).

Table 6 lists the results of the pre- and post-journal tests. Among the sub-factors of scientific attitude, only curiosity and persistence yielded scores below the significance level. Average scores for openness, criticism, cooperation, volunteering, and creativity improved, but the changes were not statistically significant.

**Table 6.** Pre- and post-test attitudes towards science factor (N = 34).

| Sub-Factor | Division | Average | Standard Deviation | Standard Error | $t$ | $p$ |
|---|---|---|---|---|---|---|
| Curiosity | Pre-test | 7.93 | 1.896 | 0.254 | 2.108 | 0.033 * |
| | Post-test | 8.98 | 2.036 | 0.284 | | |
| Openness | Pre-test | 9.12 | 1.796 | 0.313 | 1.153 | 0.358 |
| | Post-test | 9.42 | 1.748 | 0.295 | | |
| Criticism | Pre-test | 8.82 | 1.756 | 0.331 | 0.891 | 0.386 |
| | Post-test | 8.93 | 1.501 | 0.289 | | |
| Cooperation | Pre-test | 9.22 | 1.560 | 0.299 | 0.168 | 0.894 |
| | Post-test | 9.27 | 2.129 | 0.266 | | |
| Volunteering | Pre-test | 9.97 | 1.618 | 0.409 | 1.027 | 0.368 |
| | Post-test | 9.98 | 1.599 | 0.387 | | |
| Persistence | Pre-test | 8.89 | 1.793 | 0.241 | 2.118 | 0.033 * |
| | Post-test | 10.24 | 1.696 | 0.216 | | |
| Creativity | Pre-test | 9.46 | 7.699 | 0.326 | 2.103 | 0.068 |
| | Pro-test | 9.89 | 2.117 | 2.98 | | |

* $p < 0.05$.

#### 4.3.2. Post-Activity Survey

With regard to attitude towards science, we asked two questions in the post-activity survey: 'Did keeping a science journal change your attitude towards learning science?' (Table 7) and 'Did keeping a science journal change your attitude towards your daily life?' (Table 8).

**Table 7.** Post-activity attitudes to learning science (N = 34).

| | | Changed | | Unchanged |
|---|---|---|---|---|
| **Group** | **Changed a Lot** | **Changed a Little** | **Total (%)** | **Total (%)** |
| All | 3 | 12 | 15 (44) | 19 (56) |
| High | 1 | 1 | 2 (5.8) | 4 (11.8) |
| Middle | 1 | 4 | 5 (14.7) | 5 (14.8) |
| Low | 1 | 7 | 8 (23.5) | 10 (29.4) |

**Table 8.** Post-activity attitudes towards science in daily life (N = 34).

| | | Changed | | Unchanged |
|---|---|---|---|---|
| **Group** | **Changed a Lot** | **Changed a Little** | **Total (%)** | **Total (%)** |
| All | 6 | 14 | 20 (59) | 14 (41) |
| High | 1 | 3 | 4 (11.8) | 2 (5.8) |
| Middle | 2 | 5 | 7 (20.6) | 3 (8.8) |
| Low | 3 | 6 | 9 (26.6) | 9 (26.4) |

From Table 7, 56% of the participating students stated that keeping science journals did not change their attitudes towards learning science, for example:

- *Science is still difficult and confusing.*
- *I don't think keeping a science diary has anything to do with studying science.*
- *It is fun to do an experiment in science class, but this too I have to memorize. So there aren't really any changes.*

However, 44% of students thought that writing science journals helped improve their attitudes towards learning science, for example:

- *I understood scientific principles naturally through writing journals*
- *It was fun and amazing writing a journal about stuff that I usually just pass by and link them to what I learned in science class.*
- *Even though it was only for writing a science diary, I thought a lot about scientific things.*

Most of the students who found writing science journals helpful did not link learning science to tests. Our results are consistent with those of Peyton [24], who found that learners expand and link original concepts through writing science journals. We suggest that science journals can provide a great opportunity for students to think about science as being beyond material for tests and gradually learn about science through their daily lives.

From Table 8, 41% of the students responded that writing a science journal did not influence their attitudes towards their daily lives. For example, there is no particular change caused by keeping a diary:

- *I've never thought of science as being related to my daily life.*
- *I felt annoyed and pressured to keep a science journal and I do not think that it made any change in my daily life.*

In contrast, 59% of the students stated that writing science journals positively influenced their attitude towards science in their daily lives, for example:

- *I now look around my surroundings more carefully and in detail.*

- *I think about what I should be writing about for my journals, all the time; at home, school, on my way to anywhere!*

These comments suggest that students started to think about finding a topic for their science journal; during that process, they naturally acquired a habit of observing and interpreting their surroundings in their everyday life.

#### 4.3.3. Interviews

To better comprehend students' comments from the post-activity survey, we asked interviewees whether their attitudes towards studying the subject of science changed after writing their science journals. Students either responded 'yes' or 'no.' In general, students' logical thinking ability did not have a strong influence on changes in their attitude towards studying science. For example, students G and H from the high-level group and student A from the low-level group mentioned that writing journals did not have any effect on their attitudes:

- Student A: Nothing changed.
- Student G: There is no particular change. I believe that studying science is not always about memorization. It is easy to study science once I understand concepts.
- Student H: I study every subject including science focusing on the comprehension of topics. So I don't think there were any changes towards my studying attitudes after writing the science journal.

To explore the effects of writing a science journal on attitudes towards science, as well as the diverse students' perspectives on this topic, we further asked interviewees whether their attitudes towards science in their daily lives changed after writing science journals. Most students did recognize, to a certain extent, a change in their attitude, for example:

> Student E: When I just pass time in my daily life, I now observe and think about science-related topics. I kept thinking of the science diary until I found a topic for it. So, I think, this is the change.

> Student F: I did not look for science in my daily life in the past. I just went by, now when I observe some natural phenomena, I wonder why it happens and I try to find the reasons on the Internet, etc. I get some help from my parent or teacher when I cannot find the information on the web. I think that is the difference.

Despite the fact that the high-level logical thinking ability group answered that there was no change in cognition or attitude because they had always been interested in science, writing science journals encouraged them to reflect on science-related issues that they usually overlooked. Middle-level logical thinking students also replied that they now look at issues in their daily lives more carefully to find a topic for their science journal. This is consistent with the results of previous studies, which indicated that keeping a science diary changes the learning attitude of students as they observe their surroundings and search for scientific principles on their own [8]. Furthermore, reflective writing develops the ability to observe every-day phenomena from a scientific perspective [14,23].

## 5. Discussion

This study investigated the perceptions of students about how keeping a science diary affected their cognition of science, interest in science, and attitude towards science. From data, including questionnaires, interviews, and surveys, keeping a science journal develops students' affective characteristics related to science. After keeping science journals, students found science to be more relevant to their lives and revised their view of science. Furthermore, writing a science journal helped change their perception of science and provided opportunities for students to think beyond their usual concerns, which, in turn, enhanced students' general interest in science. However, the cognition of the students from the low- and high-level logical thinking groups did not change significantly among the various sub-factors of science cognition. Prior to the project, students from the high-level logical thinking group already possessed positive cognition of science and experienced and sought various ways to interact with science in and outside the classroom while students from the low-level logical thinking group generally maintained negative views towards science. Similar patterns were observed in the cases of students' interest and attitude. As a result, the findings of this study suggest that keeping a science journal can be a useful method to develop students' affective characteristics related to on science. We hope that our findings contribute to developing better pedagogies and resources for teaching science for elementary students. A major limitation of the study was that the selection of participants for individual interviews was solely based on their logical thinking ability. Future studies should examine students' personal preference and previous experience related to science activities, which significantly influence the development of students' science-related affective characteristics discussed in this study. Moreover, some students in this study perceived writing science journals to be obligatory, not voluntary. More accurate results may be drawn by studying students who write science journals of their own volition.

This study offered diverse students' perspectives on writing science journals in relation to improvements in science-related domains. Based on our results, we suggest that writing science journals can be a potential learning tool for elementary students to develop science-related affective domains, thus engaging them to more effectively learn science. Despite the recognition given to affective domains in learning and teaching, they remain a peripheral area in education, wherein much attention is focused on the cognitive domain. The results of this study will contribute to advocacy for the fulfillment of the three domains (cognitive, psychomotor, and affective) in learning and teaching science.

**Author Contributions:** Conceptualization, Y..J. and C.L.; methodology, H.K.; software, H.K.; validation, H.K. and Y.J.; formal analysis, H.K.; investigation, Y.J. and C.L.; resources, H.K.; data curation, H.K.; writing—original draft preparation, Y.J. and H.K.; writing—review and editing, H.K.; visualization, H.K.; supervision, H.K.; project administration, H.K. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

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