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Effects of Outdoor Education on Elementary School Students' Perception of Scientific Literacy and Learning Motivation

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Abstract: This study aims to explore the impact of outdoor education on senior elementary school students' perceptions of scientific literacy and learning motivation. 42 senior elementary school students (25 males, 17 females; average age = 11.6) were enrolled and divided into experimental (N = 21) and control (N = 21) groups. Participants were taught the same content about science for four weeks. The control group adopted traditional indoor teaching, whereas the experimental group adopted outdoor education. Before and after the course, each student completed the 23 items of scientific literacy and the 6 items of learning motivation scale. The results show that the experimental group had significantly higher perceptions of scientific literacy and learning motivation. The outdoor education teaching method has positive effects on the higher levels of awareness and creative development of students. These findings imply that outdoor education has a positive effect on improving students' perceptions of scientific literacy and learning motivation.

Keywords: *Elementary school students, learning motivation, outdoor education, perceptions of scientific literacy, scientific literacy.*

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Introduction

Outdoor education is a concept of education that has been used in countries across the globe (Gilbertson et al., 2022). In Australia, the Birrigai Outdoor School provides educational programs first and foremost for students from pre-school to year 12, located in a natural reserve in Australia (Duigan & Gurr, 2007). In addition, the governments of the United States and the United Kingdom have issued policies encouraging students to participate in exploring activities outside of the classroom (Brand et al., 2014; Gilbertson et al., 2022; Mullan, 2019). So, outdoor education has been an internationally adopted educational paradigm for decades (Gilbertson et al., 2022).

Outdoor education has been defined in various ways, depending on occupational and personal perspectives (Hammerman et al., 2000). However, it is not difficult to discern that scholars from all disciplines have several similar views. It is a supplement to classroom learning which refers to learning activities arranged by schools or teachers outside the classroom, such as in a corner of the campus, social education institutions, or other local environments (Bølling et al., 2018). It could be social visits, cultural exchanges, and additional experiential learning that immerse students in real-world situations (Yıldırım, 2020). Therefore, learning outside of the classroom can readily pique their curiosity and encourage them to investigate, enrich, and broaden the educational experiences of students (Eick, 2012). It enables students to appreciate the enjoyment and variety of learning. Outdoor education has the key advantages of supplementing and compensating for the inadequacies of classroom instruction, testing what has been learned in the classroom, and facilitating the transfer of learning (Gilbertson et al., 2022).

Furthermore, outdoor education has also been shown to have benefits and value in academic learning because it encourages students to interact with nature and has a strong impact on students' scientific literacy (Cotič et al., 2020; Eick, 2012; James & Williams, 2017). It increases different aspects of scientific literacy, such as the essence of science and the application of scientific knowledge, scientific awareness, affection, and skills (Durant, 1993; Fang, 2005; Laugksch, 2000; Lucas, 1983; Miller, 1983; Osborne, 2012; Roberts & Bybee, 2014; Yore et al., 2003). Moreover, outdoor education helps to improve knowledge and awareness of the natural world; it also contributes to the development of scientific skills

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as well as scientific literacy and problem-solving skills for students (Eick, 2012; Ernst & Stanek, 2006). Therefore, outdoor education is an effective way of learning, which has a significant impact on learners' personal growth, social development, and environmental protection concepts (Pirchio et al., 2021). Outdoor education may also increase students' curiosity, scientific success, and ability to behave in environmentally friendly ways (Rios & Brewer, 2014).

However, the development of scientific literacy alone is insufficient. For example, while some studies have explored the impact of outdoor education on scientific literacy, they often overlook the essential aspect of learning motivation (Holbrook & Rannikmae, 2009). Aside from students' perceptions of scientific literacy, learning motivation is an essential aspect of this study. Motivation, defined as an individual's internal psychological state that drives and sustains learning behavior, is essential for achieving educational goals (Gopalan et al., 2017; Huitt, 2011). From the literature, outdoor education emerges as a promising approach to enhance both scientific literacy and learning motivation among students. It significantly influences learning performance, with high motivation correlating positively with increased willingness to learn and academic achievement (Ryan & Deci, 2000; Tella, 2007). By connecting classroom learning with real-world experiences, outdoor education engages students in environmental science (Correia et al., 2010) and fosters curiosity (Rios & Brewer, 2014). It is effective in motivating students and bringing learning to life for those who struggle in more traditional learning environments. Those who dread the uncharted wilderness gain confidence as a result (Stevenson et al., 2021).

Despite evidence supporting the positive impact of outdoor learning on scientific literacy and learning motivation, its effects on senior elementary school students remain underexplored. Existing studies predominantly concentrate on other age groups, leaving a gap in understanding how outdoor learning specifically impacts older elementary students. This gap limits our comprehensive understanding of the effectiveness of outdoor education interventions for this demographic. By addressing these limitations, this study aims to address this gap by investigating the influence of outdoor learning on senior elementary students' perceptions of scientific literacy and learning motivation, particularly focusing on natural science subjects conducive to outdoor education implementation. The findings will inform recommendations for enhancing natural science instruction and guide future research in this area.

Methodology

Research Design

This study used a quasi-experimental design to investigate the effect of learning outside on senior elementary school students' perceptions of scientific literacy and learning motivation. The operational variable is the teaching method, which may be classified into outdoor education teaching methods and narrative teaching methods. Therefore, this study aimed to investigate how outdoor education and narrative teaching methods influence the scientific literacy and learning motivation of senior elementary school students. Students participated in an activity named *Walk around, sit, and watch the cloud* to learn about water in the atmosphere. The research design structure is shown in Figure 1.

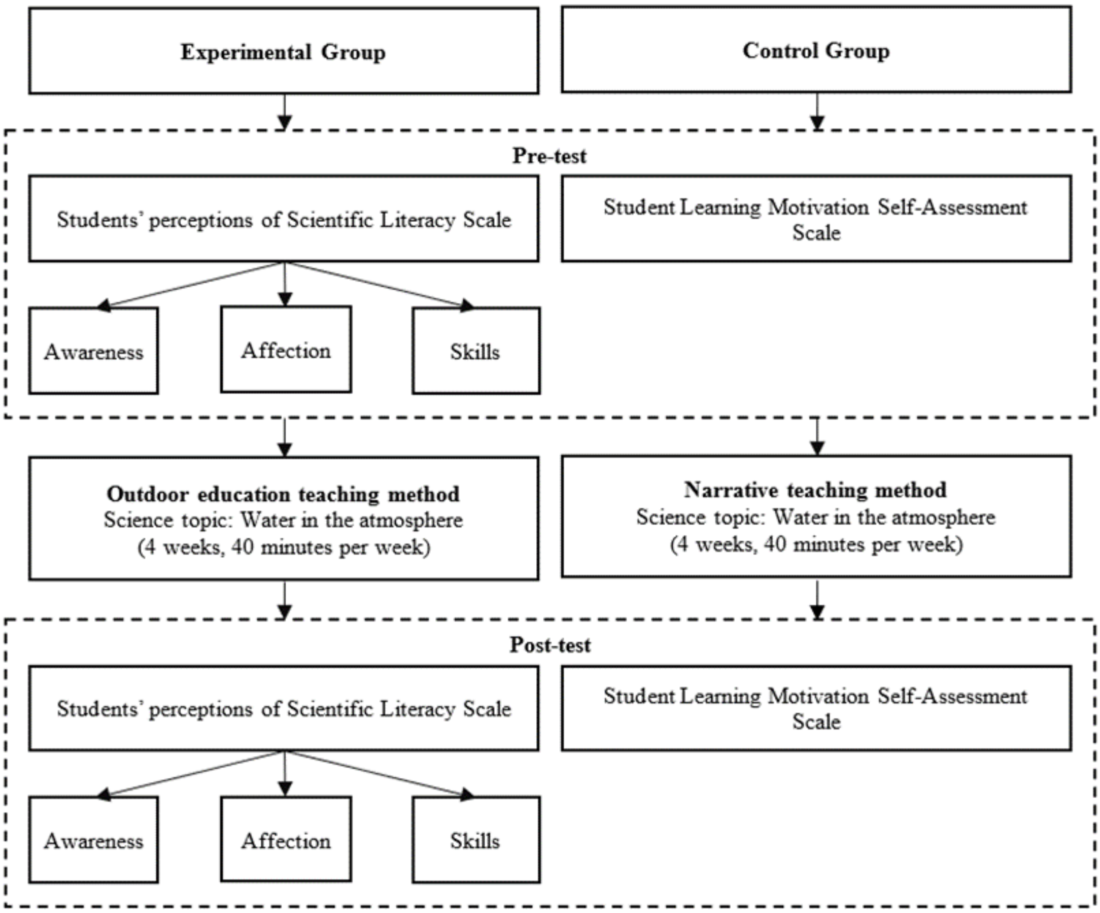

Figure 1. Research Design Structure

Participants

A total of 42 sixth-grade students in Taiwan participated in this study. There were 25 males and 17 females, with an average age of 11.6 years. They were divided into one experimental group (21 students) and one control group (21 students). All of them were taught by the same teacher during their natural lessons. During the outdoor education sessions, students engaged in an activity called "Walk around, sit and watch the cloud," aimed at enhancing their understanding of water in the atmosphere. Teachers facilitated this activity by guiding students through observations and discussions about cloud formation and the water cycle in the natural environment. Weather conditions or time constraints have made challenges to conducting outdoor activities. Therefore, the teacher carefully planned and prepared the alternative activities as backups in case of inclement weather. Additionally, managing a large group of students in an outdoor setting has been challenging for the teacher. Hence, the teacher established clear routines for students during outdoor lessons to help maintain order and engagement.

Instruments

This study used two research instruments, including the Student's Perceptions of Scientific Literacy Scale and the Student Learning Motivation Self-Assessment Scale to collect information on students' perceptions of scientific literacy and learning motivation.

Students' Perceptions of the Scientific Literacy Scale

This scale has 23 items on a Likert scale ranging from 1 (*strongly disagree*) to 3 (*general*) to 5 (*strongly agree*) that react to the students' responses. They are divided into three subscales: Student Awareness Self-Assessment Scale (8 items), Student Skill Self-Assessment Scale (7 items) and Student Affection Self-Assessment Scale (8 items). Each subscale was reviewed by three experts; the research validity was tested using the Kaiser-Meyer-Olkin (KMO) and Bartlett's sphere tests. Almost Cronbach's alpha coefficient was acceptable and had a high reality, and the KMO value coefficient was greater than .70, which indicated the validity and reality of the scale.

The Student Awareness Self-Assessment Scale was based on the revised version of Bloom's taxonomy (Krathwohl, 2002) to understand the self-assessment of students' awareness before and after joining the course. There were six main levels of awareness: remember, understand, apply, analyze, and evaluate (Krathwohl, 2002). The Cronbach's alpha coefficient in this subscale is .85, the KMO value is .73, and it has passed the Bartlett's sphere test.

The Student Skill Self-Assessment Scale was based on Simpson's (1966) skill to understand the self-assessment of students' skills before and after joining the course. It is divided into five levels: prepare, guide response, mechanical practice, skill adjust and create. The Cronbach's alpha coefficient in this subscale is .73, the KMO value is .75, and it has passed the Bartlett sphere test.

The Student Affection Self-Assessment Scale was based on Krathwohl et al.'s (1964) emotional to understand the students' self-assessment of affection before and after joining the course. It included four major categories: react, evaluate, organize, and character formation. The Cronbach's alpha coefficient in this subscale is .89, the KMO value is .84, and it has passed the Bartlett sphere test. Some samples of items in the three subscales are shown in Table 1.

Table 1. Sample Items for the Students' Perceptions of Scientific Literacy Scale

Dimension	Sample item	Level
Awareness	I can concentrate for a long time in class and remember what the teacher said.	Remember
	For unfamiliar things, I can use the knowledge I have learned to find out for myself	Apply
	I can apply the knowledge from the book to my life	Create
Skill	I know what the results of the lab procedures in the textbook will be.	Prepare
	I can also complete the experiments in the course by myself.	Mechanical practice
	I can apply what I have learned to solve problems in my daily life.	Create
Affection	I will do my best in the class activities.	React
	I am able to collaborate with other students.	Evaluate
	After taking this course, I hope to have a similar course.	Character formation

Student Learning Motivation Self-Assessment Scale

This scale is to understand the difference in students' learning motivation before and after joining the course. The scale was modified with reference to the Learning Motivation Strategies Questionnaire revised by Liu et al. (2010) with 6 items on the scale ranging from 1 (strongly disagree) to 3 (general) to 5 (strongly agree). Learning motivation was divided into three major categories: value, expectation, and volition, in accordance with the learning motivation component revised by Liu et al. (2010). The KMO value of this scale is .68, and it has passed the Bartlett's sphere test, indicating that the data is valid. The Cronbach's alpha coefficient of this scale is .79, indicating that the scale has good reliability. Some samples of items in this scale are shown in Table 2.

Table 2. Sample Items for the Student Learning Motivation Self-Assessment Scale

Sample item	Level
I would be more willing to contact relevant knowledge.	Value
I wish I could take this class again.	Expectation
I can use what I learned during this time in my life.	Volition

Data Analysis

The data from the two questionnaires were coded and analyzed using the quantitative method in SPSS Statistics 26.0. The analysis process included assessing the reliability of the questionnaires using Cronbach's alpha coefficient. Additionally, the Kaiser-Meyer-Olkin test and Bartlett's sphere test were conducted to evaluate the suitability of the data for further analysis. Moreover, descriptive statistics were performed to examine the distribution of the data and assess whether it approximated a normal distribution. Subsequently, the Shapiro-Wilk test was utilized to formally assess the normality of the data, given the sample size of 42 participants. The results indicated that the data obtained from both the control ($p = .52$; $p > .05$) and experimental ($p = .51$; $p > .05$) groups exhibited normal distributions. Based on the normality assessment, paired sample *t*-tests and analysis of covariance (ANCOVA) were employed to determine the statistical significance of the collected data. These parametric tests were chosen due to the normal distribution of the data, ensuring the validity and reliability of the subsequent statistical analyses.

Results

This study's goal is to explore the impact of outdoor education on senior elementary school students' perceptions of scientific literacy and learning motivation. Two research instruments were adapted for this study, namely the Student Students' Perceptions of Scientific Literacy Scale and the Student Learning Motivation Self-Assessment Scale.

Analysis of the Students' Perceptions of Scientific Literacy

According to the descriptive statistics from the study on students' perceptions of scientific literacy, senior elementary school students were self-evaluating their scientific literacy as follows: all levels in each dimension scored above the average of 3.0 points; in awareness, the best and lowest scores were *create* (*M* = 3.88) and *evaluate* (*M* = 3.21); in skill, *skill adjust* (*M* = 3.96) and *mechanical practice* (*M* = 3.29); and in affection, *evaluate* (*M* = 4.06) and *character formation* (*M* = 3.60). These findings suggested that senior elementary school students self-evaluated their perception of scientific literacy at an upper-middle level.

The analysis of covariance (ANCOVA) was used to examine the impact of different teaching methods on students' scientific literacy in both the control and experimental groups (Table 3). Results from the ANCOVA were statistically significant, indicating that there was a significant difference between the experimental group and the control group in the students' perceptions of scientific literacy, F (2, 39) = 369.05, $p < .05$.

Table 3. The ANCOVA Analysis Compares Groups Students' Perceptions of Scientific Literacy

Sources	*SS*	*df*	*MS*	*F*	*p*-value
Corrected model	20.78	2	10.39	391.52	.00
Intercept	0.82	1	.82	11.84	.01
Group	1.50	1	1.50	16.62	.01
Scientific literacy	10.68	2	10.68	369.05	.00
Error	2.96	39	.08		
Total	686.72	42			
Corrected total	23.74	41			

* *R*-squared = .86 (Adjusted *R*-squared = .85)

For more details about the efficiency of the teaching method, this study analyzed the students' perceptions of scientific literacy by comparing the scores in the pre-test and post-test between both groups (Table 4). The paired sample t-test results confirmed the effectiveness of the outdoor education teaching method. In the experimental group, all dimensions of scientific literacy were significantly different ($p < .05$), whereas only the skill dimension in the control group was significantly different ($p < .05$) after students joined this course. In other words, the outdoor education teaching method could improve students' scientific literacy compared to the narrative method.

Table 4. The Students' Perceptions of Scientific Literacy Between the Pre-test and Post-test for Control and Experimental Groups

Dimension	Group	Pre-test		Post-test		*t*-value	*p*-value
		M	*SD*	*M*	*SD*		
Awareness	Control	3.52	.66	3.54	.61	-.25	.81
	Experimental	3.85	.47	4.40	.48	-4.78	.00
Skill	Control	3.45	.55	3.62	.58	-3.90	.00
	Experimental	4.04	.66	4.35	.63	-4.25	.00
Affection	Control	3.27	.67	3.32	.68	-2.90	.09
	Experimental	4.45	.64	4.60	.50	-4.00	.01

Furthermore, in Table 5, the pair sample *t*-test showed that almost all levels of students' perceptions of scientific literacy in the control group were not significantly different ($p > .05$), except for some levels in skill dimensions such as *guide response* with t (20) = -2.50, $p < .05$ or *mechanical practice* with t (20) = -2.34, $p < .05$. About awareness dimension, the narrative method had a tremendously positive change in the *understanding, applying, and analyzing* levels but negative growth in the remember and evaluate levels (Table 5). One probable explanation is that students find it difficult to concentrate for long periods. McKeachie and Svinicki (2006) found that after a few minutes of narrative teaching, students' attention quickly collapsed, and students tended to become unnecessary thinkers and passive recipients of the information. As a result, the negative growth of these two aspects occurs.

Table 5. Details of the Students' Perceptions of Scientific Literacy Between the Pre-test and Post-test in the Control Group

Dimension	Level	Pre-test		Post-test		*t*-value	*p*-value
		M	*SD*	*M*	*SD*		
Awareness	Remember	3.57	.81	3.33	.80	1.75	.10
	Understand	3.45	.89	3.62	.89	-1.92	.07
	Apply	3.79	.54	3.83	.51	-1.00	.33
	Analyze	3.29	1.06	3.33	1.15	-.57	.58
	Evaluate	3.14	1.11	3.00	1.14	1.14	.27
	Create	3.76	.94	3.76	1.14	.00	1.00

Table 5. Continued

Dimension	Level	Pre-test		Post-test		*t*-value	*p*-value
		M	*SD*	*M*	*SD*		
Skill	Prepare	3.38	.59	3.67	.66	-2.83	.01
	Guide response	3.62	.74	3.86	.79	-2.50	.02
	Mechanical practice	3.29	.96	3.57	1.16	-2.34	.03
	Skill adjusts	3.69	.60	3.76	.60	-.83	.42
	Create	3.24	.82	3.36	.87	-2.02	.06
Affection	React	3.43	1.14	3.48	1.18	-1.45	.16
	Evaluate	3.55	.72	3.60	.72	-1.00	.33
	Organize	3.14	1.10	3.19	1.16	-1.00	.33
	Character formation	2.98	.62	3.05	.69	-1.83	.08

Table 6 showed that there were significant differences in the awareness dimension of students' perceptions of scientific literacy ($p < .05$) among students who joined to study with the outdoor education teaching method, indicating that the outdoor education teaching method can improve the awareness dimension of students' perceptions of scientific literacy. It is different from the control group, almost all levels had a significant difference in the experimental group.

Table 6. Details of the Students' Perceptions of Scientific Literacy Between the Pre-test and Post-test in the Experimental Group

Dimension	Level	Pre-test		Post-test		*t*-value	*p*-value
		M	*SD*	*M*	*SD*		
Awareness	Remember	4.00	.55	4.62	.59	-4.24	.00
	Understand	3.88	.57	4.57	.53	-4.93	.00
	Apply	3.79	.58	4.12	.55	-2.20	.04
	Analyze	4.14	.65	4.67	.58	-3.53	.00
	Evaluate	3.29	.90	3.95	1.07	-4.64	.00
	Create	4.00	.71	4.57	.60	-3.51	.00
Skill	Prepare	4.19	.81	4.43	.75	-2.02	.06
	Guide response	4.29	.64	4.67	.48	-2.61	.02
	Mechanical practice	3.29	1.15	3.57	1.25	-2.34	.03
	Skill adjusts	4.24	.70	4.48	.64	-2.50	.02
	Create	4.02	.95	4.40	.98	-3.70	.00
Affection	React	4.62	.59	4.67	.58	-1.45	.16
	Evaluate	4.57	.66	4.67	.53	-2.17	.04
	Organize	4.31	.72	4.45	.59	-1.83	.08
	Character formation	4.29	.82	4.62	.52	-3.35	.00

Besides, students in the experimental group were significant in almost all levels of the skill dimension, with the highest difference in the *create* level, t (20) = -3.70, $p < .05$ (Table 6), after joining this course. It indicated that senior elementary school students who participate in outdoor education have made exceptional progress at almost levels, particularly in creativity. In the control group, *prepare*, *guide response* and *mechanical practice* levels showed significant differences, while *skill adjusts* and *create* levels did not show significant differences. Therefore, both teaching methods can improve scientific literacy skills. However, compared to the narrative teaching method, senior elementary school students who implement the outdoor education teaching method have significantly improved all items of skill dimension, especially creativity.

Furthermore, Table 6 revealed disparities in the affection dimension of self-evaluation among senior elementary school students who use the outdoor education teaching method at each level. There were significant differences in the levels of *evaluation* and *character formation* after the student joined the course taught by the outdoor education teaching method. The highest and lowest difference levels were *character formation*, t (20) = -3.35, and *react*, t (20) = -1.45, respectively. For senior elementary school students in the control group, *character formation* has the highest t (20) = -1.83 among all of the levels in this dimension, while *evaluate* and the *organize* items have the lowest, t (20) = -1.00 (Table 5). However, none of the levels achieved a significant difference in this dimension. That also confirmed that receiving outdoor education teaching could improve students' affection abilities compared with narrative teaching.

Analysis of the Students' Perceptions of Learning Motivation

A descriptive statistical method was used to analyze and explain the results of the mean and standard deviation for each aspect to comprehend the learning motivation of senior elementary school students. Regarding concentration, students scored highest on *value* (M = 4.02), which suggests that students have better self-affirmation in their learning goals and value beliefs. The lowest score on *expectation* (M = 3.48) is that students are less confident in their belief in success. The scores of the three items range from 3.48 to 4.02 points, all three items are higher than the average score of 3.0 points, showing that the self-assessment of the learning motivation of the senior elementary school students belongs to the upper-middle level.

Based on the results from the ANCOVA, there were statistically significant differences, indicating that there was a significant difference between the experimental group and the control group in the students' perceptions of learning motivation, F (1, 39) = 213.01, p < .05 (Table 7).

Table 7. Differences in Learning Motivation of Different Teaching Methods

Sources	*SS*	*df*	*MS*	*F*	*p*-value
Corrected model	36.46*	2	18.23	266.84	0.00
Intercept	0.77	1	0.77	11.24	0.00
Group	1.12	1	1.12	16.46	0.00
Pre-motivation test	14.55	1	14.55	213.01	0.00
Error	2.66	39	0.07		
Total	682.11	42			
Corrected total	39.12	41			

* R-squared = .93 (Adjusted R-squared = .93)

Besides, this study also analyzed the students' perceptions of learning motivation to understand the effect between the narrative and the outdoor teaching method by comparing the scores in the pre-test and post-test between both groups (Table 8). The paired sample t-test results confirmed the effectiveness of the outdoor education teaching method. In the experimental group, there was a significant difference, t (20) = -3.51, p < .05 after students joined this course taught by the outdoor education teaching method, whereas there was not a significant difference, t (20) = -.33, p = .75 after students joined this course taught by the narrative education teaching method. In other words, the outdoor education teaching method could improve students' learning motivation compared to the narrative method.

Table 8. Differences in Students' Learning Motivation Between Outdoor Education and Narrative Teaching Methods

Group	Pre-test		Post-test		*t*-value	*p*-value
	M	*SD*	*M*	*SD*		
Control	3.17	.71	3.19	.77	-.33	.75
Experimental	4.38	.72	4.63	.51	-3.51	.00

In the experimental group, Table 9 showed that the senior students' scores who implemented the outdoor education teaching method were achieved only significantly in *expectation* category, t (20) = -3.53, p < .05 after student joined this course. Moreover, the category with the highest difference is *expectation*, t (20) = -3.53; the item with the lowest difference is *value*, t (20) = -1.45. In the control group, the results showed that there was only a significant difference in *volition* category, t (20) = 2.17, p < .05 but it was negative growth (Table 9). *Volition* was the highest difference, t (20) = 2.17, and *value* is the lowest difference, t (20) = -1.45, in all categories of learning motivation.

Table 9. Descriptive Statistics and t-test Analysis of Senior Elementary Students' Learning Motivation of the Major Categories

Category	Group	Pre-test		Post-test		*t*-value	*p*-value
		M	*SD*	*M*	*SD*		
Value	Control	3.48	1.33	3.57	1.40	-1.45	.16
	Experimental	4.57	.68	4.67	.58	-1.45	.16
Expectation	Control	2.81	.87	2.95	1.02	-1.82	.08
	Experimental	4.14	.96	4.67	.58	-3.53	.00
Volition	Control	3.24	.94	3.05	.80	2.17	.04
	Experimental	4.43	.75	4.57	.60	-1.83	.08

Discussion

This study explored the impact of outdoor education on senior elementary school students' perceptions of scientific literacy and learning motivation. The findings from the analysis of students' self-evaluations of scientific literacy reveal a positive trend, with all dimensions scoring above the average of 3.0 points. This study aligns with Becker et al. (2017), Buldur et al. (2020), Ellinger et al. (2022), and Gilbertson et al. (2022) that outdoor education significantly enhances students' awareness of scientific concepts. Moreover, the findings corroborate the notion that exposing students to natural settings fosters a deeper connection with scientific principles. However, the distinctive feature of the current study lies in its exploration of specific dimensions within scientific literacy, such as creativity in the skill domain and character formation in the affection domain. For example, students had a considerable degree of success adjusting experimental actions to real-world situations, a skill crucial for the practical application of scientific knowledge. The finding of this study adds valuable insights and shows how outdoor education contributes to multifaceted aspects of scientific literacy beyond broad awareness.

Moreover, the implementation of outdoor education, as evidenced by the statistically significant results in the ANCOVA, emerges as a potent factor for improving students' skill of scientific literacy. The effectiveness is underscored by the significant differences in all dimensions between the experimental and control groups, emphasizing the contributions of the outdoor education teaching method. Specifically, the implementation of outdoor education appears to have positively influenced various dimensions of scientific literacy, including *creativity*. The study confirmed the findings about the impact of outdoor education on skill development, particularly *creativity* (Bølling et al., 2021; Dettweiler, Becker, et al., 2017; Dettweiler, Lauterbach, et al., 2017). It could be explained that outdoor education offers a dynamic and engaging learning environment that enhances creativity within the skill dimension of scientific literacy (McAnally et al., 2018). By immersing students in real-world experiences and providing opportunities for exploration and experimentation, outdoor education stimulates curiosity, critical thinking, and problem-solving skills, all of which are essential components of scientific literacy (Pambudi, 2022). Notably, the narrative teaching method in the control group exhibited limited effectiveness, especially in dimensions such as *guide response* and *mechanical practice*, suggesting potential limitations of traditional teaching approaches in fostering certain aspects of scientific literacy. This could be attributed to the passive nature of traditional classroom settings, which may not adequately engage students or provide opportunities for hands-on learning and exploration (Bølling et al., 2021).

In terms of learning motivation, the study aligns with the broader narrative proposed by Becker et al. (2017). The observed significant differences in motivation levels, particularly in the expectation category, underscore the consistent theme that outdoor education positively influences students' overall engagement with learning. Comparing the outdoor education group with the control group, which received narrative teaching, shows the effectiveness of outdoor education in enhancing students' motivation to learn. Particularly, the experimental group showed significant improvements in *evaluation* and *character formation*, suggesting that the emotional and ethical dimensions of scientific literacy can be effectively nurtured through experiential learning in natural settings. Possible reasons for these results include the immersive nature of outdoor education, which allows students to engage directly with scientific concepts in real-world contexts. This hands-on approach fosters a deeper understanding and appreciation for scientific knowledge, thereby enhancing motivation to learn (Bølling et al., 2018; Crompton & Sellar, 1981). Additionally, the outdoor environment provides opportunities for students to develop emotional connections to scientific concepts and consider ethical implications, which can further enhance their motivation and engagement with natural science (Gilbertson et al., 2022; James & Williams, 2017; Knapp, 1989). This result offers empirical support to the argument that the outdoor environment enhances the student's learning motivation and achievement.

Conclusion

Outdoor education is a widely implemented educational concept with significant positive impacts on students, particularly in enhancing scientific literacy and learning motivation (Gilbertson et al., 2022). This research contributes to the existing body of literature by demonstrating the effectiveness of outdoor education in improving scientific literacy and learning motivation among senior elementary school students. The research findings indicated that senior elementary school students who participated in outdoor education showed significant improvements in learning motivation and all three dimensions of scientific literacy: awareness, skill, and affection. In contrast, students taught using the narrative method only demonstrated substantial gains in the skill dimension of scientific literacy. The difference in improvement between the two methods was statistically significant.

Specifically, among students taught using outdoor education, the greatest difference in the awareness dimension was observed in the "understand" item, while the smallest difference was seen in the "apply" item. In the affection dimension, the "character formation" item showed the largest difference, while the "react" item had the smallest difference. In the skill dimension, the "create" item had the largest difference, while the "prepared" item had the smallest difference.

These findings suggest that outdoor education positively impacts students' knowledge deepening and creative development. It is concluded that outdoor education can enhance senior elementary students' scientific literacy and learning motivation. Teachers are recommended to use outdoor education to provide students with richer experiences and sensory contact, thereby improving their scientific literacy and learning motivation.

Moreover, it is important that the findings of this research are considered not just in terms of how they might help to prove the value of outdoor learning, but also in terms of how they might help to improve the quality of outdoor learning lessons. When teachers carry out outdoor learning lessons, three elements should be considered, such as curriculum (content, structure, duration, and methods), participant (grade, characteristics, and interests of students), and place (the suit and novelty of the outdoor learning setting). For example, teachers should carefully prepare the content, sequencing, and duration of outdoor activities to ensure they are age-appropriate and relevant to the subject matter being taught. Moreover, teachers can provide opportunities for individual exploration, small-group collaboration, and whole-class discussions to accommodate varying learning styles and interests.

The effectiveness of outdoor learning observed in this study over four weeks suggests that outdoor education can positively impact students, even in the short term. While numerous studies have highlighted the long-term benefits of outdoor education, this research underscores the immediate positive effects it can have on students. However, certain gaps remain unaddressed in this study, particularly regarding the long-term effects of outdoor education on students' academic performance and overall development.

Recommendations

This study not only provides valuable insights into the impact of outdoor education on upper elementary students but also offers practical suggestions for teachers, administrators, and parents. Teachers should consider integrating outdoor education activities into their curriculum across all elementary grade levels because these activities can enhance students' scientific perceptions and learning motivation. Schools and educational institutions should invest in professional development programs for teachers to equip them with the necessary skills and knowledge to effectively implement outdoor education methods, emphasizing innovative teaching methodologies and outdoor learning strategies. Parents play a significant role in supporting outdoor learning experiences at home, and teachers and school principals should encourage parental involvement through activities such as nature walks, gardening projects, and outdoor explorations to extend learning beyond the classroom.

Furthermore, to enhance the applicability of the findings, future investigations should expand their scope to include students at all grade levels in elementary school. Each grade level may exhibit unique responses to outdoor education, influencing scientific perceptions and learning motivation in unique ways. Therefore, a comprehensive exploration that spans all elementary grades will facilitate a deeper understanding of the differential impacts of environmental education on elementary students.

Limitations

The primary limitation of this study lies in its only focus on upper-grade elementary students. While the findings offer insights into the specific impact of environmental education on student's perceptions and learning environment, caution must be exercised in generalizing the results to the broader elementary school population. Different developmental stages may yield varied responses to outdoor education, and therefore, generalizations to younger elementary students should be approached with circumspection.

Ethics Statements

The authors confirm that this study met the ethics/human subject requirements of the [BLINDED] at the time the data were collected.

Conflict of Interest

The authors declare no conflict of interest.

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Authorship Contribution Statement

Fan: Conceptualization, methodology, investigation, writing - original draft reparation, writing - review and editing. Tran: Conceptualization, methodology, writing - original draft reparation. Nguyen: Conceptualization, methodology, writing - review and editing. Huang: Conceptualization, methodology, investigation, writing - review and editing, data curation and project administration.

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