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Pre-service Teachers' Awareness of Informal Learning Within the Framework of Science Education and an Examination of Their Science Experiences in These Environments

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Abstract: This study aimed to examine pre-service teachers' awareness of informal learning, their science experiences in informal learning environments, and their views on the role of informal learning in science education. A concurrent mixed-methods design integrating quantitative and qualitative data was employed. The study involved 197 pre-service teachers enrolled in science education, primary education and early childhood education programmes. Quantitative data were collected using the Scale of Science experience in Informal Settings, whilst qualitative data were gathered via an open-ended written response form. Quantitative data were analysed using descriptive statistics, an independent-samples t-test and one-way ANOVA, whereas qualitative data were analysed through content analysis. The results of the study revealed that the pre-service teachers' levels of science experience in informal settings were moderate and that these levels did not show significant differences according to the variables of gender, year group and department of study. The qualitative findings, meanwhile, indicated that the pre-service teachers predominantly perceived informal learning as a learning process that takes place outside school, is related to daily life, is experience-based and involves learning by doing and experiencing. Although participants demonstrated positive awareness of informal learning, qualitative findings suggested that this awareness remained largely experiential and was not sufficiently supported by pedagogical understanding. The findings highlight the need to strengthen pedagogically oriented informal learning experiences within teacher education programmes.

Keywords: Pre-service teachers, Informal learning, Informal science experience, Science education, Mixed methods

Introduction

With the transition to the information society, significant changes have taken place in the ways in which individuals access, use and produce new knowledge. This transformation has rendered the view of learning as a process confined solely to school, the classroom and the curriculum inadequate; individuals' everyday life experiences, social interactions, digital environments and their relationships with the natural environment have also begun to feature as integral components of learning (Eraut, 2004; Livingstone, 2001; Marsick & Watkins, 2001). Accordingly, learning is increasingly recognised as an ongoing process that is not restricted to predetermined instructional settings or scheduled educational activities. Instead, it develops continuously through the wide range of situations and experiences encountered in everyday life. As lifelong learning has become a central principle in education, the visibility of the knowledge, skills and experiences that individuals acquire outside formal education processes has also grown in educational research (Candy, 1991; Jarvis, 2007; UNESCO, 2015). These developments have shown that learning cannot be adequately understood through

formal education alone, encouraging broader discussion of theoretical perspectives that clarify how formal, non-formal, and informal learning complement and interact with one another.

In the educational literature, learning processes are generally addressed under three main headings: formal, non-formal and informal learning (Coombs & Ahmed, 1974; Rogers, 2004; Schugurensky, 2000). This classification provides a conceptual framework aimed at explaining individuals' learning experiences in different contexts, rather than drawing strict boundaries between learning processes. Whereas formal learning takes place within planned and institutionalised structures, non-formal learning encompasses more flexible and semi-structured learning activities. In contrast, informal learning refers to the learning that a learner develops in real life, often unconsciously, in an unplanned and spontaneous manner (Livingstone, 2001; Marsick & Watkins, 2001; Schugurensky, 2000). In recent years, with the growing prominence of the lifelong learning approach, informal learning is increasingly recognised as an important learning process that supports a learner's cognitive, affective and psychomotor development, complements formal learning, and takes place within the natural flow of life (Colley et al., 2003; Eraut, 2004; Fenwick, 2001; Illeris, 2009; Merriam et al., 2007; Rogers, 2014). This growing interest in informal learning highlights the need to examine more closely defined within different theoretical frameworks and which aspects of it are explained.

Although the concept of informal learning is discussed from different theoretical perspectives in the literature, researchers share a common view that it is an experience-based and contextual learning process that takes place within everyday life experiences. Livingstone (2001) defines informal learning as learning that a learner engages in during real-life activities, often without a conscious intention to learn, whilst Marsick and Watkins (2001) emphasise the unplanned, unstructured and experience-based nature of this process. Schugurensky (2000), on the other hand, examines informal learning across three dimensions—spontaneous learning, incidental learning and learning through socialisation—demonstrating that this form of learning is fuelled through both personal experiences and social interaction. Similarly, Rogers (2014) notes that informal learning emerges within the natural flow of life and is constantly reshaped through the individual's interactions with their environment. When these different approaches are taken together, these perspectives suggest that the characteristics of voluntariness, flexibility, experience-based learning, social interaction, contextuality and integration with life are the distinguishing features of informal learning (Colley et al., 2003; Eraut, 2004; Fenwick, 2001). These characteristics suggest that learners play an active rather than a passive role in knowledge construction who simply receives ready-made knowledge; rather, they actively construct knowledge in line with their experiences, prior life experiences and interactions with their social environment.

The experience-based, contextual and interaction-focused nature of informal learning supports its explanation from a constructivist perspective. From a constructivist perspective, knowledge is not viewed as ready-made content transmitted directly to the learner; rather, it is a dynamic process through which learners actively build knowledge based on their prior experiences, interactions and engagement with their environment (Bruner, 1996; Fosnot, 2005; Jonassen, 1999; Piaget & Inhelder, 1972; Vygotsky, 1978). This perspective argues that learning does not occur solely through teacher-centred knowledge transfer; rather, learners construct meaning by encountering real-life problems, observing, discovering, questioning and engaging in social interactions.

According to Piaget and Inhelder (1972), individuals learn by integrating new information into their existing cognitive schemas through the processes of assimilation and accommodation. This enables new experiences encountered in informal learning environments to reorganise the individual's existing knowledge structure. However, it is also recognised that learning cannot be explained solely by individual cognitive structuring processes. Vygotsky (1978) emphasises that learning occurs not only through individual cognitive processes but also via social interactions, emphasising the important role of the individual's communication with their environment in the construction of knowledge. Interactions established with peers, teachers, family members and various social circles in informal learning environments constitute the most concrete examples of this theoretical approach in practice.

Likewise, Bruner (1996) states that learning takes place through discovery and that the learner's active participation lies at the heart of learning. Jonassen (1999), meanwhile, asserts that authentic learning environments based on real-life problems support learners in developing meaningful learning. Examples of informal learning environments include museums, science centres, nature reserves, science festivals and real-life experiences—largely align with the fundamental principles of the constructivist approach to learning in that they present learners with authentic problem situations. For this reason, informal learning can be regarded not merely as a form of learning that takes place outside school, but as a theoretically robust learning approach that enables learners to make sense of their real-life experiences, relate scientific knowledge to everyday life, and participate in active knowledge-construction processes. This theoretical framework also makes a significant contribution to

understanding why informal learning is regarded as an effective learning approach, particularly in disciplines based on experience, observation and interaction.

Science is recognised as a discipline that centres on learning through observation, experimentation, discovery and direct experience (Bybee, 2000; National Research Council, 2000). The fact that scientific concepts are directly related to everyday life, the natural environment and environmental phenomena demonstrates that science learning cannot be confined solely to teaching activities taking place in the classroom; it can also take place in out-of-school settings, natural environments, at home, and within the individual's real-life experiences (Falk & Dierking, 2000; Rennie et al., 2003). In this respect, informal learning environments contribute to making learning meaningful and lasting by enabling students to experience the concepts covered in science teaching within real-life contexts. Particularly, settings for informal learning, including museums, science centres, aquariums, zoos, nature reserves and the home environment offer students the opportunity to relate scientific concepts to everyday life, develop their sense of curiosity and apply scientific process skills within natural contexts (Bell et al., 2009; Falk & Dierking, 2013; Griffin, 2004). Research shows that these environments make significant contributions to the concretisation of scientific concepts, the enhancement of learning retention and the development of scientific literacy (Braund & Reiss, 2006; Dillon et al., 2006; Wellington & Ireson, 2012). Furthermore, it is noted that informal learning environments support the development of scientific process skills (e.g., observation, problem solving, hypothesis formulation, and experimentation) and positively influence pupils' interest, attitudes and motivation towards science lessons (Hofstein & Rosenfeld, 1996; National Science Teachers Association [NSTA], 2012; Osborne et al., 2003; Palmer, 2009). These findings demonstrate that informal learning environments should be seen as more than a complementary element of science teaching, but as important learning ecosystems that support students' scientific thinking processes.

The effective use of informal learning environments in science education depends on teachers and pre-service teachers correctly recognising the learning opportunities these environments offer and utilising them for pedagogical purposes. Consequently, developing pre-service teachers' awareness of informal learning, enabling them to link such environments to the curriculum, and enabling them to design learning experiences that foster pupils' scientific learning that directly influence the quality of science education (Avraamidou, 2014; Kisiel, 2013; Rennie & Johnston, 2007; Tal & Morag, 2007). Recent studies suggest that informal learning experiences enhance pre-service teachers' self-efficacy in science teaching, their professional self-confidence, their perspectives on science teaching, and the development of their teacher identity (Hesson & Roth, 2024; McDaniel, 2023; Pinthong et al., 2025). However, informal learning today is no longer limited to physical learning environments; With ongoing developments in digital technologies, online learning environments have also become key components of informal learning. Online experiment videos, virtual museum tours, interactive simulations and digital learning platforms enable learners to relate scientific concepts to real-life contexts and to participate more actively in their learning processes (Dede, 2014; de Jong et al., 2013; Falk & Dierking, 2013; Rutten et al., 2012). Furthermore, it is noted that augmented reality and virtual reality applications support students' motivation and attitudes towards science lessons (Cheng & Tsai, 2013), whereas digital collaborative learning environments strengthen pre-service teachers' perceptions of science learning and their participation in learning processes (Napal-Fraile et al., 2024). Recent research also reveals that digital informal learning environments increase students' participation in learning processes, support their self-regulation skills and contribute to their academic development (Liu et al., 2025). These developments necessitate a comprehensive examination not only of pre-service teachers' awareness of informal learning but also of how they interpret their physical and digital informal learning experiences within the context of science teaching.

Aims and Significance of the Study

Recent research has increasingly focused on pre-service teachers' perceptions of informal learning environments, their competence in planning out-of-school learning activities, and their self-efficacy beliefs regarding these environments. These studies demonstrate that informal learning experiences enhance pre-service teachers' self-confidence in science teaching, support the development of their teacher identity, and contribute to the development of positive attitudes towards utilising out-of-school learning environments (McDaniel, 2023; Pinthong et al., 2025). However, existing research largely focuses on the effectiveness of specific practices, self-efficacy beliefs or the planning of out-of-school learning activities, studies that simultaneously address pre-service teachers' conceptual understanding of informal learning and their science experiences in informal settings remain limited. In particular, it is noteworthy that mixed-methods studies revealing how pre-service teachers interpret informal learning and how their experiences of this form of learning mutually reinforce one another are under-represented in the literature. This situation necessitates the joint examination not only of pre-

service teachers' knowledge levels regarding informal learning but also of the meanings they ascribe to this concept and their informal science experiences.

As informal learning is a multidimensional phenomenon closely linked to individuals' experiences, perceptions and learning experiences, explaining this structure using solely quantitative or solely qualitative data may prove limited. For this reason, a mixed-methods approach was adopted in the study; in addition to quantitatively determining pre-service teachers' levels of science experiences in informal settings, the ways in which they interpret these experiences and evaluate them within the context of science teaching were also examined through qualitative data. The study therefore aims to offer a more comprehensive understanding of the relationship between pre-service teachers' awareness of informal learning and their informal science experiences, and to contribute to the development of teacher training programmes.

Accordingly, the primary objective of the research is to examine, through a holistic approach, pre-service teachers' awareness of the concept of informal learning, their views on the contributions of informal learning to cognitive, affective and psychomotor development, and their levels of science experience in informal settings. Furthermore, the research also addressed pre-service teachers' evaluations regarding the use of informal learning in science teaching and the potential benefits this learning approach could offer to pupils.

In this context, the main research question was formulated as follows: 'What are pre-service teachers' levels of awareness regarding informal learning within the framework of science education, and what are their levels of science experience in informal learning environments?'

In line with this main research question, answers were sought to the following sub-questions:

1. What are pre-service teachers' levels of science experience in informal learning environments?
2. What are pre-service teachers' levels of science experience in informal learning environments;
 - a. gender,
 - b. year group,
 - c. and the department in which they are studying?
3. What are pre-service teachers' levels of awareness regarding informal learning within the framework of science education, and to what extent do they relate this form of learning to science teaching?

Method

Research Model

This study was designed within a mixed-methods approach to examine, from a holistic perspective, pre-service teachers' awareness of informal learning within the framework of science education and their levels of science experience in informal learning environments. As the research problem required both the determination of pre-service teachers' levels of science experience in informal settings and the identification of how they perceive, interpret and relate these experiences to science teaching, it was deemed appropriate to use both quantitative and qualitative research approaches.

Mixed-methods research is an approach that combines the strengths of quantitative and qualitative approaches, thereby enabling a more comprehensive and in-depth examination of research problems. In this approach, whilst quantitative data provide generalisable findings, qualitative data reveal in detail individuals' experiences, awareness and processes of meaning-making (Creswell, 2014; Tashakkori & Teddlie, 2010). According to Creswell and Plano Clark (2017), the mixed-methods approach reduces the limitations of a single method, thereby enabling research problems to be addressed from a multidimensional perspective.

A concurrent mixed-methods design was adopted for this study. In this design, quantitative and qualitative data are gathered concurrently, analysed independently of one another, and the results of these analyses are integrated and interpreted in the final stage of the research (Creswell & Plano Clark, 2017). The main rationale for choosing the concurrent mixed-methods design is that pre-service teachers' awareness of informal learning and their science experiences in informal learning environments can be explained through two complementary data sources. Whereas the quantitative findings reveal the levels of pre-service teachers' science experiences in informal settings, the qualitative findings have contributed to explaining how these experiences are perceived, interpreted and evaluated within the context of science education. Thus, the aim was to provide a more comprehensive explanation of the research problem by comparing and integrating the findings obtained from different types of data (Creswell, 2014).

The Population and Sample of the Study

The population of the study consists of pre-service teachers enrolled at the Faculty of Education, Niğde Ömer Halisdemir University, during the 2025–2026 academic year. The sample for the study was selected through criterion sampling, a purposive sampling technique. Purposive sampling is a sampling approach that enables the selection of cases rich in information that can best elucidate the research problem. Criterion sampling, on the other hand, allows for the inclusion in the study of individuals who meet pre-determined criteria (Patton, 2015; Yıldırım & Şimşek, 2021).

The following criteria guided the selection of participants: (i) being enrolled at the Faculty of Education, (ii) being registered on one of the science teaching, primary school teaching or pre-school teaching programmes, and (iii) providing informed consent to participate in the study. These three teacher training programmes were included in the study because the students on them play a direct role in the planning and implementation of science teaching at the early childhood and primary education levels. Furthermore, the fact that pre-service teachers on these programmes have the potential to reflect informal learning environments in their future professional practice aligns directly with the aim of the study.

A total of 197 pre-service teachers who met these criteria formed the quantitative study group for the research. In the qualitative study group, the views of 126 pre-service teachers who completed the open-ended written response form in full and provided responses suitable for evaluation were analysed. Thus, the quantitative and qualitative study groups were selected from the same population; the different dimensions of the research problem were examined through two complementary data sources. Table 1 presents the demographic characteristics of the pre-service teachers in the sample group.

Table 1. Demographic characteristics of the research group

Characteristic		<i>f</i>	%
Gender	Female	145	73.6
	Male	52	26.4
Year Group	Year 1	12	6.1
	Year 2	32	16.2
	Year 3	100	50.8
	Year 4	53	26.9
Department	Science Teaching	51	25.9
	Primary School Teaching	72	36.5
	Pre-school Teaching	74	37.6
Total		197	100

As shown in Table 1, 145 of the pre-service teachers participating in the study were female (73.6%) and 52 were male (26.4%). When the distribution of participants by year group is examined, it was found that 12 were in Year 1 (6.1%), 32 in Year 2 (16.2%), 100 in Year 3 (50.8%) and 53 in Year 4 (26.9%). In terms of distribution by programme, it was found that 51 of the pre-service teachers were studying on the science teacher training programme (25.9%), 72 on the primary school teacher training programme (36.5%) and 74 on the early years' teacher training programme (37.6%).

Data Collection Tools and Process

In order to obtain both quantitative and qualitative data simultaneously, a questionnaire comprising a personal information form, the Scale of Science Experience in Informal Settings, and an open-ended written response form was used in the study. The data collection tools were selected to provide a comprehensive response to the sub-problems of the research, with each tool providing data relating to a different dimension of the research problem. The personal information form was used to determine the participants' demographic characteristics; the Scale of Science Experience in Informal Settings was used to quantitatively assess pre-service teachers' levels of science experience in informal settings; and the open-ended written response form was used to enable pre-service teachers to explain in detail their awareness, assessments and experiences regarding informal learning. This section presents information regarding the data collection tools used in the research and the data collection process.

Personal Information Form

Participant demographic information was collected using a personal information form. This form included questions regarding the pre-service teachers' gender, the department in which they were studying, and their year of study. The information obtained was used to determine the demographic distribution of the pre-service teachers participating in the study and to gather demographic data to be used as independent variables in quantitative analyses.

Scale of Science Experience in Informal Settings

The Scale of Science Experiences in Informal Settings, adapted into Turkish by Bakioğlu and Karamustafaoğlu (2021), served as the quantitative data collection instrument. This scale was selected because it assesses pre-service teachers' science-related experiences in non-school settings in a multidimensional manner and aligns directly for the quantitative component of the study. The scale was designed to assess individuals' science-related experiences in out-of-school settings. It comprises four sub-dimensions: observation, collection, activity and experimentation.

It has been reported that the scale's Cronbach's alpha internal consistency coefficient is .85, whilst the reliability coefficients for the sub-dimensions range between .71 and .87. Within the scope of this study, the scale's Cronbach's alpha internal consistency coefficient was recalculated and found to be .84. The Cronbach's alpha coefficient obtained indicates that the scale possesses sufficient internal consistency within this study group as well. The scale is organised as a three-point Likert scale. Items are rated using the options 'Never', 'Sometimes' and 'Often'.

Open-ended Written Response Form

For the qualitative component of the study, an open-ended written response form was used to gather information about pre-service teachers' awareness of the concept of informal learning and their views regarding science education. The form consists of seven questions designed to enable participants to express their own thoughts in detail.

The following questions were posed to the pre-service teachers in the open-ended written response form:

1. What does informal learning mean to you?
2. Do you assess informal learning in terms of cognitive, affective and psychomotor development?
3. What comes to mind when you hear the term 'informal learning'?
4. What are the settings for informal learning?
5. Can you evaluate informal learning regarding science education?
6. In your opinion, should informal learning be prioritised in science lessons? Could you explain your answer?
7. In your opinion, what benefits might informal learning offer to pupils?

The questions included in the form were prepared taking into account the literature on informal learning and studies in the field of science education. The open-ended written response form was submitted to three academic staff members specialising in assessment and evaluation for review in terms of scope, clarity, comprehensibility and alignment with the research objective. In line with the experts' opinions, care was taken to ensure that the questions were clear, comprehensible and consistent with the research objective; the necessary adjustments were made, and the final version of the form was produced. In this respect, the open-ended written response form aims to reveal pre-service teachers' conceptual awareness of informal learning and their ability to relate this form of learning to science teaching.

Data Collection Process

The data for the study were collected by the researchers in classroom settings from pre-service teachers studying at the Faculty of Education, Niğde Ömer Halisdemir University, during the spring term of the 2025–2026 academic year. Before data collection began, the purpose of the study was explained to the participants; they

were informed that participation was voluntary; and they were assured that the data collected would be used only for research purposes.

During the data collection process, participants were presented with a single questionnaire. This questionnaire comprised a personal information form, the Scale of Science Experiences in Informal Settings, and an open-ended written response form. Participants completed all sections individually during a single session, and the data collection process took approximately 20–25 minutes. Throughout the process, the researchers answered any questions raised by the participants and took care to ensure that the study was conducted under standardised conditions.

Following data collection, valid data were obtained from 197 pre-service teachers for use in quantitative analyses. For qualitative analyses, the views of 126 pre-service teachers who had answered the open-ended questions fully and, in a manner, suitable for analysis were included in the evaluation. The views of participants who left the open-ended questions blank or did not provide responses of a quality suitable for evaluation were excluded from the scope of the qualitative analysis.

Data Analysis

The quantitative and qualitative data obtained in the study were analysed independently of one another in accordance with the research questions; following the completion of the analysis process, the findings were interpreted from a holistic perspective. In the analysis of quantitative data, the suitability of the data set for analysis was first examined, followed by statistical analyses appropriate to the research questions. Qualitative data, on the other hand, were analysed using content analysis and evaluated in a way that supported the interpretation of the quantitative findings.

Analysis of Quantitative Data

Before commencing the analysis of quantitative data, the data set was examined to determine whether it met the assumptions of parametric tests. In this context, the normality assumption was assessed by considering the skewness and kurtosis coefficients. The arithmetic mean, standard deviation, median, skewness, kurtosis and Kolmogorov-Smirnov test results for the scale are presented in Table 2.

Table 2. Normality test results for science experience

Scale	$\bar{X}$	SD	Median	Skewness	Kurtosis	Kolmogorov–Smirnov	
						Statistics	p
Scale of Science Experience in Informal Settings	1.904	.274	1.866	.708	.565	.09	.000

Table 2 shows that the skewness value for the scores obtained from the Informal Science Experience Scale is .708, whilst the kurtosis value is .565. The literature indicates that skewness and kurtosis values falling within the ± 1 range are a strong indicator of proximity to a normal distribution, whilst values within the ± 2 range are considered to be within acceptable limits for social science research (George & Mallery, 2010; Tabachnick & Fidell, 2013; Kline, 2016). Accordingly, the fact that the obtained skewness and kurtosis values fall within acceptable limits indicates that the data satisfy the assumption of a normal distribution.

Although the p-value from the Kolmogorov-Smirnov test is found to be below 0.05, it is noted that this test is sensitive to small deviations in the distribution in large samples, and that basing a decision solely on this test result may be misleading (Field, 2018; Pallant, 2020; Razali & Wah, 2011). Furthermore, the sample size of 197 supports the applicability of parametric tests under the Central Limit Theorem (Howell, 2013; Field, 2018). Therefore, when assessing the assumption of normal distribution, the skewness and kurtosis coefficients were considered alongside the sample size; it was concluded that the data set was suitable for parametric tests (Tabachnick & Fidell, 2013; Hair et al., 2018). Homogeneity of variance, another assumption of parametric

analyses, was examined using the Levene test, and it was determined that variances were homogeneous across groups ($p > .05$).

To analyse the quantitative data, descriptive statistics were first calculated to describe pre-service teachers' levels of science experience in informal learning settings. Differences according to gender were then examined using an independent-samples t-test, while variations across year groups and fields of study were analysed through one-way analysis of variance (one-way ANOVA). Statistical analyses were performed using a significance level of .05.

Analysis of Qualitative Data

The qualitative data from the study were analysed using content analysis. During the content analysis process, participants' responses were first read repeatedly to identify meaningful statements. Subsequently, statements conveying similar meanings were grouped under codes, and categories and themes were derived from these codes. The analysis process was conducted using an inductive approach. The findings are presented alongside their frequency values.

Validity and Reliability of the Research (Trustworthiness)

Various validity and reliability measures were implemented to strengthen the scientific quality of the quantitative and qualitative data collection and analysis processes in the study. In the quantitative dimension, a measurement instrument with previously established validity and reliability was used; furthermore, the internal consistency coefficient for the data obtained from the research group was recalculated to verify the reliability of the scale in this study.

On the qualitative front, the views of three different subject matter experts were sought to ensure the content validity of the open-ended written response form; the data collection instrument was finalised following the necessary adjustments made in line with the experts' recommendations. During the data analysis process, coding was carried out independently by the researchers; the codes were subsequently compared to identify instances of agreement and disagreement. Coding consistency was evaluated using the Miles and Huberman (1994) reliability formula: $\text{Reliability} = \text{Agreement} / (\text{Agreement} + \text{Disagreement}) \times 100$. The analysis yielded an inter-coder agreement of 89%, indicating acceptable coding reliability.

To enhance the credibility of the research, direct quotations from participants' views were included in the presentation of the findings; this ensured that the themes and categories identified were supported by participants' statements. Furthermore, data triangulation was achieved by evaluating quantitative and qualitative findings together, and care was taken to interpret the research findings in a holistic manner.

Ethical Approval of the Research

The research was carried out in accordance with the Guidelines on Scientific Research and Publication Ethics for Higher Education Institutions. No procedures or practices that conflict with the ethical principles set out in these Guidelines were involved at any stage of the study.

Ethics Committee Approval Details

Name of the ethics committee conducting the review: Niğde Ömer Halisdemir University Ethics Committee

Date of the ethics review decision: 30 April 2026

Ethics review document reference number: 2026/06-28

Results and Discussion

This section presents the quantitative and qualitative findings obtained in line with the sub-problems of the research. The quantitative findings present the levels of science experience among pre-service teachers in informal settings, along with variations in these levels according to the variables of gender, year group and

department of study. The qualitative findings, meanwhile, present the data obtained from the open-ended written response form organised by theme, category, code and frequency.

Pre-service Teachers' Levels of Science Experience in Informal Settings

Descriptive statistical results regarding the scores obtained from the Science Experience in Informal Settings Scale, used to determine pre-service teachers' levels of science experience in informal settings, are presented in Table 3.

Table 3. Distribution of science experience scores

Scale	n	$\bar{X}$	Mode	Median	SD	Lowest–highest scores	Possible scores
Scale of Science Experience in Informal Settings	197	1.904	2	1.866	.274	43.00–84.00	30.00–90.00

The findings indicate that pre-service teachers' science experiences in informal settings are generally of a moderate level. The mean score obtained from the scale ($\bar{X} = 1.904$; $SD = .274$) corresponds to the 'sometimes' level on the three-point Likert scale. This finding suggests that pre-service teachers occasionally participate in science-related experiences in informal settings; however, these experiences do not reach a level characterised by regularity and continuity. Furthermore, the concentration of scores in the middle section of the scale's possible score range indicates that there are similar trends regarding informal science experiences amongst the participants.

Comparison of Levels of Science Experiences in Informal Settings According to Demographic Variables

Findings Relating to the Gender Variable

Gender-based differences in pre-service teachers' levels of science experience in informal settings were examined using an independent-samples t-test. The findings are presented in Table 4.

Table 4. t-test results by gender

Scale	Gender	n	$\bar{X}$	SD	df	T	p	Cohen's d
Scale of Science Experience in Informal Settings	Female	145	1.901	.255	195	-0.263	.793	.04
	Male	52	1.912	.323				

Descriptive statistics indicate that the mean science experience scores of female and male pre-service teachers in informal settings are very similar. This finding suggests that there is no notable difference based on the gender variable. According to the results of the independent samples t-test, there is no statistically significant difference in the levels of science experience of pre-service teachers in informal settings based on the gender variable ($t(195) = -.263$; $p > .05$). The Cohen's d effect size value of .04 indicates that the effect of the gender variable on levels of science experience in informal settings is negligible. In other words, when the research findings are evaluated in terms of both statistical significance and effect size, they reveal that pre-service teachers' levels of science experience in informal settings exhibit similar characteristics regardless of gender.

Findings Relating to Year Groups

Table 5. Science experience by year group

Scale	Year Group	n	$\bar{X}$	SD
Scale of Science Experience in Informal Settings	Year 1	12	1.869	.219
	Year 2	32	1.908	.215
	Year 3	100	1.924	.300
	Year 4	53	1.871	.267

To provide an initial overview of pre-service teachers' levels of science experience in informal settings across grade levels, descriptive statistics were calculated. The corresponding results are presented in Table 5. Upon examination of the descriptive statistics, it can be seen that the mean science experience scores of pre-service teachers in informal settings show minor differences according to year group. However, it is noteworthy that these differences do not indicate a distinct divergence in terms of score distribution. Differences in pre-service teachers' levels of science experience in informal settings across grade levels were examined using a one-way analysis of variance (ANOVA). The results are reported in Table 6.

Table 6. ANOVA results by year group

Scale	Source of variance	Sum of squares	df	Mean of squares	F	p	η^2	Significant Difference
Scale of Science	Between-group	.112	3	.037				
Experience in	Within-group	14.630	193	.076	.491	.689	.008	None.
Informal Settings	Total	14.742	196					

According to the results of the one-way analysis of variance, there is no statistically significant difference in pre-service teachers' levels of science experience in informal settings according to their year of study ($F(3, 193) = .491$; $p = .689$). The calculated eta-squared ($\eta^2 = .008$) effect size indicates that the effect of year group on levels of science experience in informal settings is low. This finding suggests that pre-service teachers' science experiences in informal settings are largely independent of the year group in which they are studying, and that there is no significant differentiation between year groups. In other words, the year group variable accounts for approximately 0.8% of the total variance in informal science experience.

Findings Relating to the Department of Study Variable

In order to determine whether pre-service teachers' levels of science experience in informal settings showed a significant difference according to the department in which they were studying, descriptive statistics were first calculated and the results are presented in Table 7.

Table 7. Science experience by department

Scale	Departments	n	$\bar{X}$	SD
Scale of Science	Science Teaching	51	1.947	.299
Experience in Informal	Primary School Teaching	72	1.879	.278
Settings	Pre-school Teaching	74	1.898	.251

Descriptive statistics show that the mean scores for science experience in informal settings among pre-service teachers enrolled in science education, primary education and pre-school education programmes are very similar. This indicates that there is no significant difference in scores between the programmes.

Differences in pre-service teachers' levels of science experience in informal settings across academic departments were examined using a one-way analysis of variance (ANOVA). The findings are reported in Table 8.

Table 8. ANOVA results by department

Scale	Source of variance	Sum of squares	Df	Mean of squares	F	p	η^2	Significant Difference
Scale of Science	Between-group	.143	2	.071				
Experience in	Within-group	14,599	194	.075	.948	.389	.010	None.
Informal Settings	Total	14,742	196					

According to the results of the one-way analysis of variance, there is no statistically significant difference in pre-service teachers' levels of science experience in informal settings depending on the programme they are studying ($F(2, 194) = .948$; $p = .389$). The calculated eta-squared ($\eta^2 = .010$) effect size indicates that the influence of the teacher training programme on levels of science experience in informal settings is low. Consequently, the research findings reveal that pre-service teachers' levels of science experience in informal settings exhibit similar characteristics regardless of the teacher training programme they are enrolled in.

The quantitative findings have provided a general framework regarding pre-service teachers' levels of science experience in informal settings. In order to explain these findings in greater detail, pre-service teachers' views on informal learning were examined through qualitative data and are presented below.

Qualitative Findings

Perceptions of Informal Learning

To determine pre-service teachers' awareness of informal learning within the context of science education, the following open-ended written response form items were used: "What does informal learning mean to you?", "Do you evaluate informal learning in terms of cognitive, affective and psychomotor development?", "What comes to mind when you hear the term 'informal learning'?" and "What are informal learning environments?", were analysed using content analysis. The analysis revealed that the pre-service teachers' statements fell into four main categories: conceptual definition, developmental assessment, perception of settings, and conceptual ambiguity. The findings regarding the categories, codes and frequencies are presented in Table 9.

Table 9. Conceptual awareness of informal learning

Category	Code	f
Conceptual Definition	Learning outside school/institutions	42
	Unplanned, spontaneous and natural learning	34
	Learning through daily life and experience	28
	Learning as non-formal/informal education	12
	Lifelong and continuous learning	10
	Student/learner-centred, active and self-directed learning	10
Formative assessment	Cognitive development	52
	Emotional development	31
	Motor/psychomotor development	27
	Multi-domain development	29
Environmental awareness	Home, family and immediate environment	78
	Street, neighbourhood, community and everyday living spaces	72
	Social learning environments	65
	Parks, gardens and open spaces	54
	Museums, science centres, aquariums and zoos	41
	Community education, courses, seminars and workshops	40
	Natural environments	38
Conceptual uncertainty	Don't know/blank	42 / 10

The findings presented in Table 9 indicate that pre-service teachers largely perceive informal learning as a learning process based on out-of-school experiences, everyday life experiences and the individual's active participation. Furthermore, participants stated that informal learning contributes to cognitive, affective and psychomotor development; they did not view the settings in which learning takes place as being limited solely to non-school institutions but also considered various contexts of daily life within this scope.

In the conceptual definition category, it was observed that pre-service teachers most frequently defined informal learning as learning taking place outside school or institutions ($f=42$), unplanned, spontaneous and natural learning ($f=34$), and learning through daily life and experience ($f=28$). To a lesser extent, informal learning was characterised as non-formal/non-formal education ($f=12$), with an emphasis on lifelong and continuous learning ($f=10$) and individual-centred and self-directed learning ($f=10$). These findings indicate that pre-service teachers largely interpret informal learning in a manner consistent with the fundamental conceptual framework in the literature. In particular, the emphasis on out-of-school learning and everyday life experiences reveals that participants perceive informal learning not merely as taking place in specific physical settings, but as a continuous learning process occurring within the natural flow of life. The views expressed by participants, such as "Learning through experience outside school involves experiences that are not tied to a programme" (P1), "It is learning that develops spontaneously and without planning" (P6) and "It refers to the experiences we gain from life" (P56), also support this assessment.

In the developmental assessment category, it was found that pre-service teachers most frequently associated informal learning with cognitive development ($f=52$). In addition, views were expressed suggesting that informal learning contributes to affective development ($f=31$), multi-domain development ($f=29$) and psychomotor development ($f=27$). When the findings are evaluated collectively, it is evident that pre-service teachers perceive informal learning not merely as a process for acquiring knowledge, but as a holistic approach to learning that supports an individual's various areas of development.

In the ‘perception of environment’ category, it is evident that pre-service teachers assess informal learning environments from a very broad perspective. Participants most frequently cited the home, family and immediate surroundings ($f=78$), the street, neighbourhood, community and everyday living spaces ($f=72$), and social learning environments ($f=65$) as settings where informal learning takes place. These were followed, in order, by parks, gardens and open spaces ($f=54$); museums, science centres, aquariums and zoos ($f=41$); community education centres, courses and workshops ($f=40$); and natural environments ($f=38$). This finding demonstrates that pre-service teachers do not limit informal learning solely to planned out-of-school learning environments; rather, they view the various social and physical environments encountered in an individual’s daily life as a natural part of learning.

Finally, it was observed that a small number of participants left some questions blank or answered ‘I don’t know’. Whilst this finding indicates that the vast majority of pre-service teachers have developed a certain level of awareness regarding the concept of informal learning, it also reveals that a limited number of participants experienced uncertainty in defining and explaining the concept. Overall, it can be said that pre-service teachers’ awareness of informal learning is centred on out-of-school learning, everyday life experiences, active participation and holistic development.

Relating Informal Learning to Science Teaching

Table 10. Informal learning and science teaching

Category	Code	<i>f</i>
Tendency to use in science teaching	Informal learning should be prioritised	71
	Should be preferred depending on the context	14
	Should not be preferred	19
Contribution to science education	Enables learning through observation, experimentation and hands-on experience	42
	It is suitable as science lessons are related to nature and the environment	38
	It facilitates conceptualisation and ensures long-term retention	29
Benefits for the pupil	Learning by doing and experiencing, through practice and experience	52
	Lasting learning/deep learning	48
	Real-life skills/linking to everyday life	34
	Social-emotional development	31
	Curiosity, exploration and investigative behaviour	27
	Creativity and problem-solving	22
	Concretisation/understanding of abstract concepts	18
Limited/negative outlook	Incorrect learning/lack of focus on the goal	11
Conceptual ambiguity	Don’t know/blank	33 / 30

In order to determine how pre-service teachers relate informal learning to science teaching, the responses to the open-ended written response form questions “Can you evaluate informal learning within the framework of science teaching?”, “In your opinion, should informal learning be prioritised in science lessons? Can you justify your answer?” and “In your opinion, what benefits might informal learning provide to pupils?” were analysed using content analysis. The analysis revealed that the pre-service teachers’ views fell into five main categories: the tendency to use informal learning in science teaching, its contribution to science teaching, its contribution to students, limited/negative views, and conceptual ambiguity regarding. The findings regarding the categories, codes and frequencies obtained are presented in Table 10.

The findings presented in Table 10 indicate that the vast majority of pre-service teachers regard informal learning as an effective and complementary component of science teaching. Participants stated that informal learning would make significant contributions to the teaching process, particularly because, by the very nature of science lessons, it supports processes such as observation, experimentation, discovery and linking to everyday life. Furthermore, whilst some participants noted that its implementation should be planned according to the subject matter or teaching conditions, a small number of participants expressed the view that informal learning should not be favoured in science teaching.

In the category of usage trends in science teaching, a significant proportion of pre-service teachers stated that informal learning should be prioritised in science lessons ($f=71$). In contrast, some participants indicated that it would be more appropriate to use this approach depending on the subject, student level or implementation conditions ($f=14$), whilst a limited number of participants stated that it should not be prioritised ($f=19$). This finding indicates that the vast majority of pre-service teachers regard informal learning as a natural component of science teaching, whilst also holding differing perspectives on the planning of the implementation process.

In the 'contribution to science teaching' category, the most frequently highlighted views were that it supports observation, experimentation and hands-on learning ($f=42$); that it is considered suitable for this learning approach because science lessons are related to nature and the environment ($f=38$); and that it enhances the retention of learning by making it more concrete ($f=29$). Participants emphasised that science teaching should not be limited solely to activities carried out in the classroom environment; they stressed that daily life and the natural environment are an important part of the learning process. These assessments indicate that pre-service teachers tend to integrate science teaching with real-life experiences. The views expressed by participants, such as 'Science should be prioritised because it is everywhere' (P15), 'Learning in nature is more memorable' (P3) and 'It makes it easier to understand' (P40), support this finding.

In the 'contribution to the student' category, pre-service teachers identified the most important contribution of informal learning as 'learning by doing and gaining experience' ($f=52$). This was followed, in order, by 'lasting and deep learning' ($f=48$), 'real-life skills and linking to everyday life' ($f=34$), 'social-emotional development' ($f=31$), curiosity, exploration and investigative behaviour ($f=27$), creativity and problem-solving skills ($f=22$) and the concretisation of abstract concepts ($f=18$). These findings reveal that pre-service teachers view informal learning not merely as an approach that supports academic achievement, but as a holistic learning process that simultaneously supports pupils' cognitive, affective and social development. The participants' statements such as "It provides experience and practical knowledge" (P21), "Deep learning occurs through hands-on experience" (P38), "It ensures lasting learning" (P20) and "What is learnt is not forgotten but becomes permanent" (P82) also support this assessment.

However, within the 'limited/negative views' category, it was observed that some pre-service teachers expressed the view that informal learning could lead to incorrect learning or might not always be sufficient for achieving teaching objectives ($f=11$). Furthermore, it was noted that some participants left the relevant questions blank or responded with 'I don't know'. Nevertheless, when the overall findings are considered together, it can be said that the vast majority of pre-service teachers view informal learning as an important complement to science teaching; in particular, they believe that this approach will make significant contributions to pupils' learning processes, especially in terms of learning by doing and experiencing, linking learning to real life, and long-term retention.

In this study, pre-service teachers' levels of science experience in informal settings, their awareness of informal learning, and their perception of how this form of learning relates to science teaching were examined from a holistic perspective within the framework of a mixed-methods approach. The quantitative findings from the study revealed that pre-service teachers' levels of science experience in informal settings were generally moderate and that these levels did not differ significantly according to the variables of gender, year group and department of study. In contrast, the qualitative findings showed that pre-service teachers largely perceived informal learning as a learning process that takes place outside school, is related to everyday life, is experience-based and occurs through 'learning by doing'; however, they experienced limitations in systematically explaining this form of learning from a pedagogical perspective and relating it to teaching processes. When the quantitative and qualitative findings are evaluated together, it becomes clear that pre-service teachers' experiences and awareness of informal learning are not entirely inadequate; however, these experiences are not sufficiently supported by the theoretical and pedagogical knowledge required to translate them into the teaching process. In this respect, the research contributes to a more comprehensive explanation of the relationship between pre-service teachers' levels of experience with informal learning and the ways in which they interpret these experiences, thanks to the integrative perspective provided by the mixed.

The moderate levels of science experience in informal settings observed among pre-service teachers indicates that the participants were not entirely unfamiliar with informal learning processes; however, it also suggests that these experiences have not yet fully translated into a conscious, systematic and pedagogically structured understanding of learning. The conceptual ambiguities revealed in the qualitative findings, the difficulties encountered in defining informal learning, and the fact that some participants responded with 'I don't know' or left the question blank can be regarded as significant indicators supporting the moderate level of experience scores identified in the quantitative findings. In other words, although pre-service teachers encounter and

experience informal learning situations in their daily lives, they may struggle to explain these experiences as a theoretical and pedagogical concept. When assessed from the holistic perspective provided by the mixed-methods approach, it becomes clear that the moderate levels of experience identified in the quantitative findings can be explained by the qualitative findings, and that the pre-service teachers' awareness of informal learning remains largely at an experiential level.

This finding is consistent with Livingstone (2001), who notes that although individuals have numerous informal learning experiences in their daily lives, they often do not consciously recognise this learning. Similarly, Schugurensky (2000) and Eraut (2004) emphasise that the implicit, spontaneous and unstructured nature of informal learning makes it difficult for individuals to define this form of learning at a conceptual level. Consequently, the finding in the present study that, although pre-service teachers have positive experiences of informal learning, they struggle to explain the concept in terms of its pedagogical dimensions, is consistent with theoretical explanations regarding the nature of informal learning. This situation also suggests that, although pre-service teachers are individuals who have experienced informal learning, they require support in structuring these experiences into a planned pedagogical approach that can be utilised in the teaching process.

Pre-service teachers' levels of informal science experiences did not vary significantly across gender, year group and department of study, and that the calculated effect sizes were quite low, suggests that informal science experiences are shaped more by individuals' personal interests, life experiences, learning opportunities and environmental conditions than by demographic characteristics. This finding is consistent with the dynamic nature of informal learning, which is grounded in individual experiences and contextual contexts. The qualitative findings, in which pre-service teachers associate informal learning environments with the home, family, immediate neighbourhood, parks, museums, science centres and various aspects of daily life, also support this assessment. In other words, pre-service teachers' experiences of informal learning can be explained more by the diversity of learning opportunities they encounter individually and the ways in which they make use of these opportunities, rather than by specific demographic characteristics.

This finding from the research is consistent with the results reported by Anderson et al. (2006), Kisiel (2013) and Behrendt and Franklin (2014), which reveal that pre-service teachers are aware of the potential of out-of-school learning environments; however, they face various difficulties in integrating these environments into the teaching process in a conscious and planned manner. Likewise, Eshach (2007) and Braund and Reiss (2006) note that when strong pedagogical links cannot be established between formal education and informal learning environments, pre-service teachers may struggle to use these environments as effective teaching tools. The qualitative findings of this study, in which pre-service teachers predominantly described informal learning in terms of its experiential aspect, whilst offering limited explanations regarding how it should be planned within the teaching process and linked to the curriculum, also support these studies.

Taken together, the quantitative and qualitative findings suggest that it becomes clear that pre-service teachers possess positive experiences and awareness regarding informal learning; however, they require theoretical knowledge and practical experience to translate these experiences into pedagogical practice. This situation demonstrates that merely introducing informal learning environments in teacher training programmes is insufficient; it is also necessary to provide practice-based learning experiences aimed at linking these environments to the curriculum, integrating them into lesson plans, and utilising them effectively within the teaching process.

The qualitative findings of the research reveal that pre-service teachers strongly associate informal learning with science teaching. Participants stated that informal learning would make significant contributions to science teaching, particularly in terms of learning by doing and experiencing, observation, conducting experiments, making abstract concepts concrete, enhancing the retention of learning, establishing links with everyday life, and fostering a sense of curiosity. These findings suggest that pre-service teachers view informal learning not merely as an out-of-school activity, but as a complementary learning approach that supports the very nature of science teaching. These assessments, which feature prominently in the qualitative findings, reveal that pre-service teachers have developed an awareness of the role of informal learning in science teaching; however, they also suggest that they require more detailed pedagogical knowledge regarding how to translate this awareness into the teaching process.

This finding from the research aligns with the views of the National Research Council (2000) and Bybee (2000), who emphasise that science education gains meaning through observation, experimentation, discovery and interaction with the environment. The findings of both studies suggest that students' active involvement in learning and their engagement with real-life experiences facilitate the understanding of scientific concepts.

Similarly, Falk and Dierking (2000) and Bell et al. (2009) state that out-of-school learning environments offer rich contextual and experiential learning opportunities that support science learning. In this context, the findings of the present study align strongly with the relevant literature in that they show that pre-service teachers regard informal learning environments as a natural extension of science teaching.

It is also noteworthy that pre-service teachers associate informal learning specifically with lasting and meaningful learning. Participants stated that learning experiences taking place outside the classroom contribute to the concretisation of science concepts, their connection to everyday life and the long-term retention of learning. These assessments are consistent with Braund and Reiss (2006), who noted that informal learning experiences integrated with formal teaching processes deepen students' conceptual understanding. Likewise, Dillon et al. (2006) and Griffin (2004) emphasise that museums, natural environments and everyday life contexts offer significant learning opportunities for the concretisation of science concepts. Consequently, the emphasis on retention, concretisation and linking to everyday life—frequently expressed by the participants in this study—aligns significantly with the literature supporting the complementary role of informal learning in science education.

Another notable finding of the study is that pre-service teachers view informal learning as a learning process that fosters curiosity, discovery and a desire to investigate. It is well known that curiosity and interest are key determinants of learning in science education. Osborne et al. (2003) and Palmer (2009) note that students' interest in and motivation towards science lessons significantly influence the quality of the learning process. Hidi and Renninger (2006), meanwhile, state that situational interest arising in experience-based learning environments can develop into individual interest over time. In this context, the fact that pre-service teachers regard informal learning as an approach that arouses curiosity and encourages discovery suggests that informal learning environments can be viewed not only as settings for acquiring knowledge but also as pedagogical environments that strengthen students' motivation to learn science.

However, one of the most striking findings of the research is that, although pre-service teachers are aware of the contributions informal learning can make to science teaching, they are unable to provide detailed explanations regarding how such learning environments should be planned, how they should be linked to the learning outcomes in the curriculum, and what methods should be used to assess learning outcomes. An analysis of the qualitative findings reveals that the vast majority of participants strongly emphasised aspects of informal learning such as learning by doing and experiencing, long-term retention, and linking learning to everyday life; however, they expressed more limited views regarding the pedagogical planning required to transform these learning experiences into the teaching process. This situation indicates that pre-service teachers' awareness of informal learning has developed largely at an experiential level, but that this awareness has not yet been integrated with their teaching design and implementation competencies.

This finding is consistent with the findings of Kisiel (2013) and Tal and Morag (2007), who noted that although pre-service teachers recognise the educational potential of out-of-school learning environments, they lack the necessary skills to integrate these environments into their teaching programmes. Consistent with this view, Anderson, Kisiel and Storksdieck (2006) state that teachers and pre-service teachers often view informal learning environments as complementary activities that support teaching; however, they encounter various difficulties in the process of transforming these environments into a planned and systematic teaching strategy. The qualitative findings of this study also support these works; they indicate that pre-service teachers possess a strong awareness of the value of informal learning, but that they require the development of pedagogical knowledge and practical skills to translate this awareness into the teaching process.

When assessed from the holistic perspective provided by the mixed-methods approach, the quantitative findings—which indicate that pre-service teachers' levels of science experience in informal settings are moderate—and the pedagogical planning shortcomings revealed in the qualitative findings can be regarded as complementary results. In other words, pre-service teachers are able to identify informal learning environments and recognise the contributions these environments can make to science teaching; however, they do not yet appear to have fully developed the practical competencies required to integrate this potential into the teaching process in a conscious, planned and curriculum-aligned manner. This finding highlights that merely introducing informal learning environments in teacher training programmes is insufficient; it also demonstrates the need to provide practice-based learning experiences that equip pre-service teachers with the skills to integrate these environments into the curriculum, design activities, manage the implementation process and evaluate learning outcomes.

Overall, this research reveals that pre-service teachers have developed a positive awareness of informal learning and have largely grasped the potential of informal learning environments in science teaching. However, when the quantitative and qualitative findings of the research are evaluated together, it becomes clear that this awareness has not yet been fully transformed into the pedagogical competencies required for effective use within the teaching process. Pre-service teachers regard informal learning as an important learning approach that supports learning by doing and experiencing, concretises science concepts, enhances the retention of learning, and facilitates the establishment of meaningful links between science teaching and everyday life. However, it is evident that this positive approach is not sufficiently reflected in pedagogical processes such as the integration of informal learning environments into the curriculum, the planning of appropriate learning activities, and the assessment of learning outcomes.

In this regard, the research indicates that the fundamental need of pre-service teachers regarding informal learning is not so much to develop awareness, but rather to develop the professional knowledge and skills that will enable them to translate their existing awareness into teaching practice. Consequently, it is not sufficient to treat informal learning merely as a theoretical component within the teacher training process. It is important that pre-service teachers are supported through practice-based learning experiences so that they can relate museums, science centres, nature areas, science festivals and other out-of-school learning environments to the learning outcomes in the curriculum; plan activities for these environments; manage the learning process; and assess learning outcomes. It is believed that this approach will contribute to the more conscious and effective use of these environments in science education by transforming pre-service teachers' awareness of informal learning into pedagogical competencies.

Conclusion

In conclusion, this research has demonstrated that the fact that pre-service teachers hold positive perceptions of informal learning does not, in itself, mean that they will be able to utilise these environments effectively. The key requirement is for pre-service teachers' awareness to be supported by the pedagogical competencies necessary to integrate it into the processes of instructional design, implementation and assessment. Therefore, addressing both the theoretical foundations and practical processes of informal learning within teacher training programmes will make a significant contribution to the use of out-of-school learning environments as a natural and planned component of science teaching. This study makes an original contribution to the literature by examining pre-service teachers' awareness of informal learning alongside their science experiences in informal settings using a mixed-methods approach, thereby highlighting the gap between awareness and pedagogical competence.

Recommendations

Drawing on the findings of this study, the following recommendations are offered, informal learning be incorporated into teacher training programmes in a more systematic and practice-oriented manner. The research findings indicate that pre-service teachers possess positive perceptions of informal learning, but that these perceptions are not sufficiently reflected in their teaching practice. Therefore, teacher training programmes should place greater emphasis on theoretical and practical learning experiences that support pre-service teachers in conceptualising informal learning not merely as out-of-school or unplanned learning, but as a pedagogical approach to learning that can be linked to the curriculum and is capable of being planned and assessed.

In this regard, in courses such as science teaching, teaching principles and methods, out-of-school learning environments and teaching practice, practice-based activities can be planned to enable pre-service teachers to link informal learning environments to the learning outcomes in the curriculum. Pre-service teachers can be encouraged to design teaching activities, prepare lesson plans, develop student worksheets and create assessment tools to evaluate learning outcomes for museums, science centres, nature reserves, parks, aquariums and other out-of-school learning environments. In this way, pre-service teachers can not only become familiar with informal learning environments but also develop the pedagogical competencies required to integrate these environments effectively into the teaching process.

The findings of the research indicate that digital informal learning environments should also be given greater prominence in the teacher training process. To ensure that digital learning environments—such as online experiment videos, virtual museums, simulations, augmented reality applications and virtual laboratories—can be used effectively in science teaching, pre-service teachers must be equipped with the skills to assess the

educational potential of these environments, select reliable digital content and utilise it for pedagogical purposes. In this way, the integration of digital informal learning opportunities with both in-class and out-of-class learning processes can be supported.

In future research, the awareness and experiences of pre-service teachers studying at different universities, on different teacher training programmes and at different year groups regarding informal learning could be examined comparatively. Furthermore, through experimental and quasi-experimental studies, the effects of informal learning-based teaching practices on pre-service teachers' pedagogical competencies, their ability to utilise out-of-class learning environments, and their attitudes towards science teaching, as well as on pupils' academic achievement, motivation and interest in learning science, can be assessed (Eshach, 2007; Palmer, 2009). Furthermore, through longitudinal studies, it is possible to track how the awareness of informal learning developed by pre-service teachers during their university years is reflected in their teaching practices in their professional lives. In this way, more comprehensive and in-depth findings regarding the long-term effects of experiences related to informal learning in the teacher training process can be obtained.

Pre-service teachers should be provided with practical experiences designed to help them relate informal learning environments—such as museums, science centres, nature reserves, parks, aquariums, zoos, digital platforms and everyday life contexts—to science teaching. In this process, pre-service teachers should be expected not only to visit these environments but also to prepare activity plans for them, establish alignment between learning outcomes and activities, develop student-guided questions, and create tools for assessing learning outcomes. In this way, it will be possible to use informal learning environments not merely as supplementary activities but as a planned and purposeful part of science teaching. The use of digital informal learning environments in science teaching should also be supported. Online experiment videos, virtual museums, simulations, augmented reality and virtual laboratory applications can contribute to pre-service teachers' ability to design accessible informal learning experiences. However, for these environments to be used effectively, pre-service teachers must be equipped with critical evaluation skills regarding the reliability, scientific accuracy and pedagogical appropriateness of digital content.

Future research could involve a comparative analysis of pre-service teachers' awareness of and experiences with informal learning across different universities, teacher training programmes and year groups. This would reveal how perceptions of informal learning vary according to institutional, regional and programme-specific factors. Furthermore, experimental or quasi-experimental studies could examine the effects of informal learning-based practices on pre-service teachers' pedagogical competence, their attitudes towards science teaching, their ability to utilise out-of-class learning environments, and on pupils' academic achievement, motivation and attitudes towards science (Eshach, 2007; Palmer, 2009). Furthermore, longitudinal studies can track how the awareness of informal learning developed by pre-service teachers during their university years is reflected in their professional practice after graduation. In this way, more comprehensive findings regarding the long-term effects of informal learning on the teacher training process can be obtained.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

* The research was conducted in accordance with the Guidelines on Scientific Research and Publication Ethics for Higher Education Institutions. Ethics committee approval was obtained from the Niğde Ömer Halisdemir University Ethics Committee on 30 April 2026 (Decision No. 2026/06-28). The authors declare that the scientific ethical and legal responsibility of this article belongs to the authors.

Conflict of Interest

* The authors declare that there is no conflict of interest.

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