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Testing Rural Early Educators Attitudes toward Children's Outdoor Recreation in Nature and Science: a new framework for exploring early educators' situated science teaching

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Introduction: Early childhood educators' dispositions toward science learning in outdoor environments play a critical role in fostering young children's engagement with science. However, existing tools do not sufficiently capture the values, beliefs, and experiences that shape these dispositions, especially in rural contexts. This study introduces a new framework and development of associated tool-the Testing Rural Early Educators' Attitudes toward Children's Outdoor Recreation in Nature and Science (TREE-ACORNS)-to assess early educators' perspectives on outdoor science learning.

Methods: A sample of 108 early childhood educators, 66% of whom identified as residing in rural areas, completed the TREE-ACORNS survey. Preliminary validation of the TREE-ACORNS constructs was conducted using a structural equation modeling (SEM) framework to explore the relationships among constructs related to values for outdoor recreation, science teaching beliefs and costs, and science-related practices.

Results: Findings provide preliminary evidence that teachers' expectations and values around children's outdoor recreation are associated with their perceived science teaching costs, which in turn are indirectly related to their science beliefs, instructional practices, and support for outdoor learning. Additionally, rural-residing teachers reported lower perceived costs for science instruction and higher engagement in outdoor activities, indicating potential contextual strengths in rural early education settings.

Discussion: These results suggest that outdoor recreation and experiences may serve as effective entry points for promoting early science learning. The lower science-related costs reported by rural educators highlight a promising opportunity to leverage existing attitudes and experiences in rural communities to support high-quality science education in early childhood.

KEYWORDS

early childhood education, situated expectancy-value theory, rural, outdoor learning, science teacher attitudes

Introduction

Informal science learning has increasingly been recognized to occur outdoors (Bustamante et al., 2018), yet most of the primary research in early science teaching contains no explicit reference to outdoor environments (e.g., Maier et al., 2013; Gerde et al., 2017). This is despite the 15%-30% of an average preschool instructional day, which should be dedicated to "outdoor time," as designated in quality rating scales (e.g., the Early Childhood Environments Rating Scale, Harms et al., 2005). A scan of commonly used preschool science teaching surveys [e.g., the Preschool Teacher Attitudes and Beliefs toward Science Teaching questionnaire (P-TABS), the Science Teaching and Environment Rating Scale (STERS), the Preschool Rating Instrument for Science and Mathematics (PRISM), Brenneman et al., 2011; Clark-Chiarelli et al., 2011; Maier et al., 2013] indicates multiple questions about natural phenomena most likely to be observed outdoors (e.g., the sun, changing leaves, and insects), without inquiring about outdoor learning beliefs, activities, or materials.

Although previous research has documented the relationship between informal outdoor science learning in settings such as zoos or children's museum exhibits and early learning outcomes (Caporaso et al., 2022; McGuire et al., 2020; Marble et al., 2021), less has investigated how outdoor learning might be supported in more formal early care and education (ECE) settings. Similarly, although research has also previously documented older rural students' science, technology, engineering and math (STEM) motivations and attainment (Irvin et al., 2017; Saw and Agger, 2021; Starrett et al., 2022), less has investigated how younger rural students and their teachers may acquire and transmit science motivation and attainment. Early childhood education teaching values and practices lay the early childhood foundation of science interest and motivation, specifically through teacher transmission of identity and interest, which often occurs in early childhood and elementary school (Cian et al., 2022; Cohen et al., 2021) and in formal and informal outdoor contexts, such as parks, zoos, and playgrounds (Bustamante et al., 2018; McGuire et al., 2020, 2021). This early foundation is built primarily through exposure to high-quality informal science learning experiences (Liu and Schunn, 2020) facilitated by adult and young adult role models who themselves value science (Mulvey et al., 2020).

However, a review of existing early childhood science teaching scales and measures reveals significant gaps in their designs. The weaknesses include little or no reference to outdoor learning in questions about the teaching environment, activities, and materials used; lack of construct and ecological validity for rural caregivers,[1] who may have increased value and access to outdoor STEM learning (Eason et al., 2023; Wen et al., 2013); and a lack of conceptual alignment with dominant motivational theories in science education.

In the present study, we address these limitations by exploring if rural early childhood teachers differ from non-rural teachers in their outdoor values, science beliefs, and the outdoor and science-based activities they engage in with children in their classrooms. We ground these questions within the Situated Expectancy-Value Theory (SEVT; Eccles, 1994; Eccles and Wigfield, 2020) and assess how survey respondents' expectancies, utility values, attainment values, and associated costs influence outdoor classroom-based science teaching practices.

Outdoor learning in early science

We frame this review based on previous studies showing outdoor experiences may be important for promoting children's early science interest and achievement through its influence on cognitive skills (Kuo et al., 2019; Rodrigues and Hestenes, 2025; Trina et al., 2024) and that rural educators have more proximity to Wen et al. (2013) and engagement with (Seaman et al., 2024) outdoor spaces. We argue that the intrinsic value teachers place on personal nature and outdoor experiences will directly influence their values and the perceived cost of providing outdoor experiences and science activities for children in their care. We also argue that the values teachers place on nature and children's outdoor experiences will indirectly influence their science beliefs and the science activities and experiences they provide their students. We predict that teachers from rural regions of our southeastern sample will differ from teachers from urban regions in terms of outdoor costs, outdoor practices, and science costs. Teachers from rural regions will perceive lower outdoor costs (OC) and lower science costs (SC), and through lowered OC, SC may provide more science experiences for their students than urban teachers due to living in a region with more outdoor access.

Rurality, outdoor learning, and science

Rural parents have previously reported the outdoors as a common informal learning context for math and STEM-supportive interactions (Eason et al., 2023), and this research study investigates whether rural early educators may have similar perceptions regarding outdoor learning. In the absence of geographic proximity to traditional resources for early science learning (e.g., libraries and museums; Hartman et al., 2017; De Marco and Vernon-Feagans, 2013), outdoor spaces may, therefore, be an ecologically and culturally valid context for diverse rural caregivers to engage in science learning. Rural access to early informal science opportunities is important because those experiences predict later identity and self-competence in science domains (Dou et al., 2019; Goff et al., 2019) and because rural students may have fewer opportunities to take advanced STEM courses than their peers (Irvin et al., 2017). Therefore, the early years (preschool-kindergarten) represent an important window for building rural students' later science interests and achievement (Showalter et al., 2023), especially in outdoor and natural science domains and disciplines, which may be more accessible in rural communities (Avery and Hains, 2017; Saw and Agger, 2021). To understand why rural early educators may matter, we next briefly attend to how "rural" is situated in the literature.

Situating rural

Geospatial definitions of rural vary according to discipline, with the most accepted definitions in K-12 education deriving from the National Center on Education Statistics (NCES) Locale Codes, and most developmental studies in ECE using Beale (Vernon-Feagans and Cox, 2013) or Rural-Urban Continuum Codes (RUCA; see Eason et al., 2023, for an example). However, demographic and

1 Although our manuscript describes ECE educators, we use the term "caregivers" when describing other's research on non-teacher adults who may teach children in rural areas, where there is less center-based care, and many families educate their young children in non-center-based settings (De Marco et al., 2009), including family home child care (Henly and Adams, 2018) or with kin (Smith, 2002).

population-based studies has shown that survey respondents' self-perception of rurality and associated barriers and limitations may be discordant with national definitions of rurality (Onega et al., 2020). Rural residence can also be obscured by proximity to metropolitan areas (Lichter et al., 2021), in which housing sprawl and population growth outward from urban centers can envelop otherwise traditionally "rural" communities. Thus, rural early educators' NCES-defined geospatial categorization may or may not be as clearly linked to their access to science professional development and community contexts for doing science as would seem.

More continuous measures of rurality (e.g., Waldorf and Kim, 2018), and self-report measures of rurality (e.g., Brinkhof et al., 2023) may be alternative methods that capture the nuance and variability in how early educators perceive their geospatial address, and how that relates to their expectancies, costs and values for teaching science outdoors. Our approaches to capturing this nuance will be discussed more in the methods.

To summarize, rurality is a complex construct that may relate to early educators' access to the outdoors, access and use of materials and informal science learning opportunities, and their intrinsic values and motivation to engage with science teaching in their classrooms. Rurality is important because, although studies in early literacy (Myrtil et al., 2019) and math (Eason et al., 2023) have explored geographic differences in adults' beliefs and practices regarding early learning, to our knowledge, no studies have yet explored these differences for outdoor science learning, although the outdoors is a recognized strength of rural communities (Seaman et al., 2024). To acknowledge the complexity that rural residence may bring to early educators' motivations for outdoor and early science teaching, we suggest a new framework, wherein rurality "situates" early educators in proximity to a particular context (outdoor spaces) that may promote science learning and argue that rurality could be viewed as an asset for outdoor science interests and motivation.

A new framework for rural early educators

Previous studies have characterized early educators' self-efficacy for supporting classroom science learning (Gerde et al., 2017), parental value for outdoor activity (McFarland et al., 2011), and the quality of outdoor childcare environments in general (including a dimension for interactions, DeBord et al., 2005). However, no measure, to our knowledge, has yet examined educators' motivations for supporting science learning as situated *within* outdoor contexts, nor has any instrument applied this type of measurement for rural contexts, where early educators may have increased access to green space relative to urban counterparts (Wen et al., 2013) yet reduced access to professional development (Glover et al., 2016) on topics of science and outdoor learning. In using the term "situated," we are referring to Eccles and Wigfield's (2020) acknowledgment that motivation is contextually or situationally bound; thus, we reason that contexts, such as outdoor learning or rural communities, may be supportive of ECE teacher's utility values and expectancies for success in teaching science.

Children's early experiences with and approaches to learning science are precursors to their later science identity, persistence and achievement (Leibham et al., 2013; Morgan et al., 2016; Saçkes et al., 2010). Similarly, early educators' motivations for providing informal and playful *outdoor learning experiences* may serve as a precursor to their similar motivations for *science teaching and* inform their science teaching practices (McWayne et al., 2022; Sharifnia, 2021).

Early educators' beliefs and values about outdoor and science learning

Prior research on early educators' beliefs and values around outdoor and science learning have often focused on how teachers' *self-efficacy* informs their practices, which may promote student *interest* and *engagement,* often referred to as *approaches to learning* (Bustamante et al., 2018). Our study aims to address questions about how teacher *values* for outdoor learning can serve as a precursor to science teaching and practices and how this could differ geographically.

Motivations for outdoor and science learning are important because, although an increasing body of research focuses on adult beliefs (Gerde et al., 2017) and attributes (Leech, 2024) that can support young children's science motivation and learning, less research has investigated these beliefs from the explicitly motivational perspective of the adults themselves (see Gerde et al., 2017 and Oppermann et al., 2021, for exceptions). Thus, we note two problems with the existing research on early science teaching that we aim to address in this article.

First, although rural disparities in access to STEM education are more widely recognized in the literature on older students, little research to date attends to the same geospatial dimensions in early science learning. Research in experiential education and recreation (e.g., Seaman et al., 2024) and developmental psychology (e.g., Bowers et al., 2021; Eason et al., 2023) document that outdoor experiences and learning in green and blue spaces (Wen et al., 2013) may be a relative strength of rural communities. However, no studies that we are aware of to date have focused on those geospatial dimensions of science teaching and learning in ECE. Thus, we hypothesize that outdoor learning is an important neglected dimension of science teaching in ECE and that situating science *within* outdoor experiences that are familiar and accessible could motivate rural early educators to engage with science (Seaman et al., 2024).

Second, of the limited existing literature on motivations for teaching science in the early years, most is aligned either with principles, such as supporting children's mastery motivation (Haber et al., 2021) from the growth mindset literature (Dweck, 2012) or with adults' self-efficacy beliefs (Maier et al., 2013; Gerde et al., 2017; Oppermann et al., 2021), which draws from social cognitive theories (e.g., Bandura, 1997, 2012). Given STEM education's predominance of expectancy-value frameworks (Wang and Degol, 2013; Zhang and Bae, 2020), which focus on expectancies for success and intrinsic, utility, and attainment value for the content (e.g., Eccles, 1994, 2005; Simpkins et al., 2006), we hypothesize that early educators' motivations for engaging with outdoor and science learning may also fit well with the situated expectancy-value framework. Most importantly, we believe the *situated* nature of both outdoor learning and of rural communities access to and investment in outdoor recreation (Seaman et al., 2024) may influence rural early educators' motivations to engage with science in those spaces. In applying SEVT to our model, we briefly describe the predominant social-cognitive view on early childhood science teaching efficacy before contrasting it with expectancy-value frameworks.

Early care and education and science beliefs

Children's time in ECE is an optimal time for encouraging their scientific curiosity (Greenfield et al., 2017) due to the primary importance placed on discovery and play in most ECE settings (Akman and Güçhan Özgül, 2015; Zosh et al., 2022). Yet, observational studies have demonstrated that $< 6\%$ of early educators' instructional time may be dedicated to science (Tu, 2006). However, some research suggests comparatively more embedded science teaching may occur through play (Piasta et al., 2014). These missed opportunities appear to be due to a lack of content knowledge (Barenthien et al., 2020; Gerde et al., 2017), an essential component of the Next Generation Science Standards (NGSS), as well as a potential lack of training on how to engage in the scientific and engineering practices (such as asking questions and making hypotheses) and model conceptual thinking around cross-cutting concepts (such as cause and effect). The existing literature on early educators' science beliefs and attitudes have drawn from a social-cognitive lens to investigate their self-beliefs and efficacy for teaching science, but expectancy-value frameworks may be a more appropriate lens through which to understand science learning in the unique context of ECE in rural communities.

K-12 education and science expectancies and values

Situated Expectancy-Value Theory (SEVT; Eccles-Parsons et al., 1983; Eccles and Wigfield, 2020) provides a framework for understanding how rural early educators perceive and engage with outdoor science education that acknowledges place and is consistent with the motivational literature on older students. SEVT typically examines how survey respondents' expectancies, utility values, attainment values, and associated costs influence their STEM trajectories, dependent on their situation, in this case, rural residence. In our case, we apply SEVT to understand how rural early educators' intrinsic values around the outdoors relate to their values, expectancies, and costs for teaching science and ultimately promote their science practices. In contrast to self-efficacy frameworks used in previous evaluations of early educators' self-reported science teaching (Gerde et al., 2017), which emphasize individual beliefs in one's ability to execute specific tasks, SEVT takes a broader perspective on the contextual and value-driven factors that shape teaching practices. Next, we briefly define each component of SEVT in the context of ECE teachers' outdoor and science teaching.

Expectancies

Expectancies in SEVT frameworks refer to respondents' beliefs about their likelihood of success in STEM education, which can be influenced by various contextual factors. Rural teachers often face unique challenges, such as limited resources and pre-service or ongoing professional development opportunities (Glover et al., 2016), which can influence their expectations for success in STEM teaching (Rutherford et al., 2017). While self-efficacy frameworks focus primarily on individual confidence and skills, SEVT theory integrates these expectancies with perceptions of the broader value and costs associated with STEM teaching. For rural early educators, expectancies for success might be considered the inverse of costs, which are more well-established as barriers to educators' desire to engage with teaching certain subjects.

Costs

Costs in SEVT frameworks refer to respondents' perceptions of how investing time in STEM education may take away from other subjects, be difficult to engage in due to resource constraints, or be difficult due to effort, stress or time investment. Costs may vary depending on systemic issues such as lack of material resources (Hartman et al., 2017), distance from informal STEM learning opportunities (Hartman et al., 2017; De Marco and Vernon-Feagans, 2013), or unavailable pre-service or professional development (Glover et al., 2016), rather than personal inadequacies, affecting their overall motivation and effectiveness in STEM instruction. For rural early educators, the substantial investment required to deliver effective science instruction could affect their motivation and perceived value. However, for educators who value nature and outdoor recreation, less cost might be given to investments in outdoor activities.

Values

Values in SEVT frameworks refer to respondents' intrinsic values (such as enjoyment of nature), utility values (such as the relevance of science education to students' lives), and attainment values (such as perceived personal importance of teaching science) engaging in a particular learning activity. In rural settings, where both teachers and students may have limited exposure to some types of science careers (Saw and Agger, 2021), teachers' utility value for science education could be diminished. On the other hand, in rural settings, teachers and students likely have increased exposure to nature, which could promote their utility value for science learning if it led to career aspirations for outdoor occupations such as recreation, agriculture, forestry, etc. Teachers are a powerful transmitter of utility value for STEM to students (Dicke et al., 2021; Han et al., 2022; Parrisius et al., 2020), and students' utility value for science learning relates directly to their future course and career trajectories (Asher et al., 2023; Shin et al., 2022). Put simply, a teacher who believes science learning will prepare their students for specific types of **science** learning and careers will have students who are more likely to internalize that utility and go on to pursue those careers. This contrasts with self-efficacy frameworks, which concentrate on how teachers' belief in their own capabilities impacts their teaching, rather than how they perceive the relevance of the subject matter to students.

Rural early educators' heritage *values* and increased access to outdoor contexts for early learning may be a unique place-based strength (Bashan et al., 2021; National Academies of Sciences, Engineering and Medicine, 2024) that could serve as a lever to increase their motivation and effectiveness in

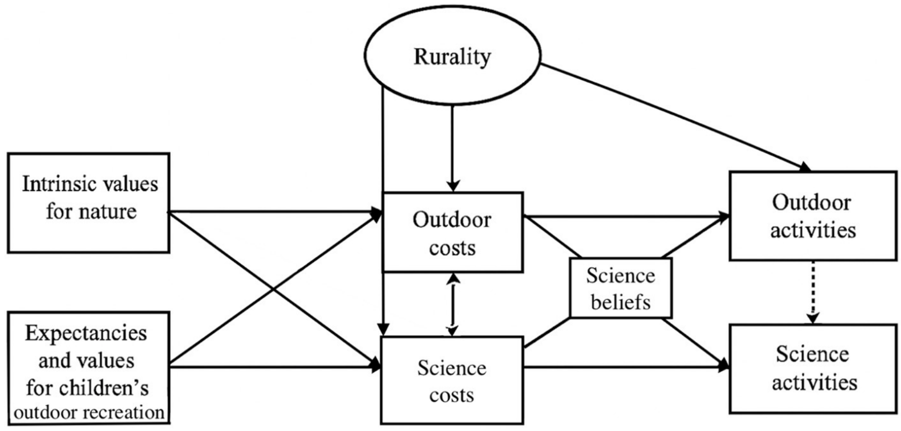

FIGURE 1
Hypothesized model of teachers' outdoor costs, science costs, beliefs, and outdoor and science activities as influenced by rurality.

offering science instruction. Previous research has shown that rural residence is associated with increased access to green and blue space in general (Wen et al., 2013) and that increased time in nature is associated with positive environmental attitudes in adults and children (DeVille et al., 2021; Liu and Green, 2024), as well as with science interest and learning (Jung et al., 2019; Kuo et al., 2019; Skalstad and Munkebye, 2022).

Our review of these separate yet interrelated bodies of research highlights a gap and justifies the development of our Testing Rural Early Educators Attitudes toward Children's Outdoor Recreation in Nature and Science (TREE-ACORNS) model aimed at measuring motivation for early science teaching *within* outdoor contexts. This study is especially important as rural communities and schools seek to address opportunity gaps in STEM by cultivating science interest in the early years (Hartman et al., 2017).

Research aims

Working from the idea that a child's early science learning may be supported by well-designed outdoor experiences (Villarroel et al., 2018), we hypothesize the intrinsic value rural ECE teachers place on their own time outdoors could, directly and indirectly, influence their perceived values for and cost of providing outdoor opportunities and subsequently, outdoor *science* opportunities for children in their care (Cheng et al., 2023; Ernst and Tornabene, 2012; Ernst, 2014; Shume and Blatt, 2019), and ultimately influence science practices (McWayne et al., 2022; Sharifnia, 2021). In this research study, we assess if ECE teachers' intrinsic personal value for nature [items derived from Parental Attitudes toward Nature (PAN); McFarland et al., 2011, and renamed Personal Values for Nature (PVN)] and expectancies and utility values toward children's outdoor recreation [items derived from the Parental Attitudes toward Children's Outdoor Recreation (PACOR), McFarland et al., 2011, renamed Expectancies and Values for Children's Outdoor Recreation (EVCOR)] directly relate to their perceived cost of providing outdoor and science opportunities. We also assess if PVN and EVCOR scores relate to children's outdoor recreation indirectly through the perceived cost of providing outdoor experiences for children, and if outdoor experiences influence science practices.

We further explore if a teacher's perceived cost of providing outdoor experiences for children relates to science cost, science beliefs, and retrospective reports of teacher's outdoor and science experiences with their class. Finally, we examine urban-rural differences in outdoor costs, science costs, and retrospective reports of outdoor experiences. We predict that teachers from rural regions will show lower outdoor costs, lower science costs, and higher levels of outdoor activities than urban teachers (Bashan et al., 2021). A figure depicting these hypothesized relations can be seen in Figure 1.

Methods

Participants

Participants were 108 pre-or in-service early childhood educators enrolled in an online asynchronous baccalaureate program at a 4-year public university located in the southeastern Appalachian region of the United States. Approximately 66% of the sample self-reported rural residence, with 84% white, 10% African American, 5% Hispanic/Latine, and 1% other. All participants were employed or had recently been employed, with 82% reporting full-time employment, 7% part-time employment, 5.5% not working but had recently been employed, and 5.5% other categories such as student teaching. Most participants were employed in either community-located and publicly funded pre-kindergarten settings (18%), pre-kindergarten or kindergarten classrooms located within public schools (25%), in Head Start (7%) or in developmental delay classrooms (6%). Of note, 20% of participants were employed in private childcare settings, and 13% were employed in "other" settings, such as after-school programs or as itinerant/floating teacher assistants. See Table 1, for more information on the descriptive characteristics of the sample.

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TABLE 1 Means, standard deviation, and correlations for all study variables.

Variable	1	2	3	4	5	6	7	8	9	10
1. Urban vs. rural	–	–	–	–	–	–	–	–	–	–
2. Outdoor cost	−0.05	–	–	–	–	–	–	–	–	–
3. Values nature	−0.02	−0.22*	–	–	–	–	–	–	–	–
4. Values Rec	0.05	−0.49**	0.36**	–	–	–	–	–	–	–
5. Science cost	0.12	0.72**	−0.12	−0.55**	–	–	–	–	–	–
6. Science beliefs	−0.01	−0.26**	0.30**	0.35**	−0.37**	–	–	–	–	–
7. Retrospective outdoor	−0.22*	−0.10	0.13	0.28**	−0.26**	0.31**	–	–	–	–
8. Science materials	−0.14	−0.11	0.23*	0.21*	−0.24**	0.02	0.21*	–	–	–
9. Science readings	−0.12	0.14	−0.00	−0.10	−0.05	−0.01	0.06	0.48**	–	–
10. Science tools	−0.12	−0.12	0.19*	0.17†	−0.29**	0.08	0.26**	0.71**	0.53**	–
N	108	108	108	108	108	108	108	108	108	108
Mean	0.34	1.83	5.25	5.46	2.15	3.69	1.63	3.01	2.34	3.00
SD	0.47	0.90	0.59	0.41	1.05	0.46	0.61	0.70	0.74	0.92
Min	0	1	3.26	4.35	1	2.61	1	1.5	1	1
Max	1	4.25	6	6	4.75	4.61	3	4	4	4

Values Nature = intrinsic personal value for nature; Values Rec = expectancies and values for children's outdoor recreation (EVCOR).
$^{*}p < 0.05$; $^{**}p < 0.01$. †indicates approaching significance.

Table 2 contains information on differences between the urban and rural participants.

Procedure

Participants responded to a web-based survey through the Qualtrics platform while enrolled in coursework during the spring 2023 or fall 2024 semesters. The study was approved by the Institutional Review Board, and informed consent was obtained.[2] Participants were able to receive blinded course credit for participation, up to 1% of their grade, using a numerical code received at the end of the survey. There were 119 original respondents. Data were screened for missingness and duplicated surveys, and surveys with <40% completion rates, those completed by candidates who had not yet begun internship and had never worked in ECE before, or those completed by identical IP addresses and consented with a second time were excluded from analyses, leaving a final sample of 108 participants. Source measures for the items included in the survey are described below.

Measures

Nature values

Items indexing respondents' personal values for nature (PVN) and Expectancies and Values for Children's Outdoor Recreation (EVCOR) were adapted from the Parental attitude toward Nature (PAN; McFarland et al., 2011) and Parental Attitude toward Children's Outdoor Recreation (PACOR; Hammond et al., 2011) scales following expert content validation. Our PVN items index adult caregivers' self-perceptions of nature, with items such as "I wish I knew more about nature" rated on a Likert-style scale from 1 ("Strongly disagree") to 6 ("Strongly agree"). Our adapted EVCOR items index adult caregivers' costs, attainment, and utility values for *children's* experiences with nature, with items such as "Outdoor activities overstimulate [my students]" and "Taking part in outdoor time builds up [my students'] independence" rated on the same Likert-style scale. Negatively valence items were reverse coded. The PVN scale has 15 items, and, therefore, sum scores can range from 15 to 90; however, participants' mean scores were averaged across items and ranged from 3.26 to 6. Higher scores indicate a more positive view toward nature. The EVCOR scale has 21 items and sum scores can range from 21 to 126. Participants' mean scores were once again averaged across items and ranged from 4.35 to 6. Higher scores on the EVCOR indicate more positive views toward children's outdoor recreation. Internal consistency for the PVN in this sample was $\alpha = 0.88$, and for the EVCOR was $\alpha = 0.84$.

Outdoor costs

Respondents were asked a variety of questions, indexing their costs and barriers to motivation for outdoor learning and physical activity. Four items indexing respondent costs related to the outdoors were adapted using survey questions from the Attitudes Toward Science survey (ATS survey; Van Egeren et al., 2007; Von Blum, 1998). The items were "Because of other things I have to do, I don't have enough time for outdoor activities with my students." and "It takes too much effort for me to help my students

2 The approved protocol was for confidential data collection, with personally identifiable information (PII), such as geolocation, transformed into a deidentified format following data collection and other PII, such as consents, always stored in a separate location.

TABLE 2 Descriptive statistics by self-reported rurality.

Variable	Urban (0), (34%)	Rural (1), (66%)	*p*-value
Race			
White	70.30	90.60	0.035
Black or African American	16.20	6.25	
Hispanic	10.80	3.12	
Asian	2.70	–	
Gender (female = 1)	97.30	100.00	0.366
Childcare type			
NC Pre-K or K in a K-5 school	18.9	31.25	0.297
NC Pre-K in a childcare center	25.00	14.30	
Private childcare or school	32.30	20.31	
Head start	5.56	7.94	
Developmental delay center/classroom	8.33	11.1	
Other	8.11	14.37	
Education			
Associate degree	70.30	68.30	0.470
Bachelor's degree	21.60	20.60	
Graduate/professional degree	5.41	1.59	
High school degree or equivalent	2.70	9.50	
Income			
<$10,000	2.70	1.56	0.478
$10,001-$29,999	10.80	14.10	
$30,000-$49,999	29.70	28.10	
$50,000-$69,999	21.60	25.00	
$70,000-$99,999	29.70	15.60	
$100,000-$149,999	2.70	12.50	

Urban = 0, rural = 1. Dashes indicate that no participants fell into that category. Percentages may not total 100 due to rounding. P-values are from Chi-square tests.

be physically active," "It requires too much effort for me to get materials I need to do outdoor activities with my students," and "Helping my students be physically active makes me feel stressed." Items were rated on a 7-point scale from "Not true at all" (=1) to "Very true" (=7). Internal consistency for these items $\alpha = 0.75$.

Science costs and beliefs

Respondents were also asked a variety of questions indexing their beliefs about and costs and motivations for teaching their students science. Four items indexing respondent costs related to science were measured using the original survey questions from the ATS survey (Van Egeren et al., 2007; Von Blum, 1998). The items were "Because of other things I have to do, I don't have enough time for doing science with my students." and "It takes too much effort for me to help my students do well at science." "It requires too much effort for me to get materials I need to do science activities with my students." and "Helping my students with science activities makes me feel stressed." Items were rated on a 7-point scale from "Not true at all" (=1) to "Very true" (=7). Internal consistency for these items was $\alpha = 0.78$. Thirteen items indexing respondent science beliefs were also measured using survey questions from ATS survey (Van Egeren et al., 2007; Von Blum, 1998). The ATS items asked about respondents' own interest and motivation to teach science, as well as their utility and attainment values for teaching science, with items such as "I am interested in science" and "Learning science helps children learn in other areas" and "[Early childhood] teachers are important for helping children learn about science." Because items from this scale encapsulate both self-efficacy and utility for science, we refer to these as "beliefs." These were rated using a 5-point Likert scale from "Strongly disagree" (1) to "Strongly agree" (5). Internal consistency for these items was $\alpha = 0.80$.

Retrospective science activities

Three measures taken from The Home Science Interview (HSI; Van Egeren and Stein, 2012) were combined to form a latent factor measuring retrospective science activities. The three HSI items asked how frequently students accessed science-related community activities, engaged in science-related reading, and interacted with science-related technology/games, toys, and tools (total items 26). "Science-related" materials which teachers could report offering access to included play animals, bugs/spiders, plants/weather, space, dinosaurs, robots, and Legos. These items were scripted with the form "How often do your students have *access* to play with the following thing?" and were rated "Never," (1) "Once or twice a week," (2) "Three to six times a week," (3) or "Every day" (4). Internal consistency for these items was $\alpha = 0.80$. "Science-related tools," five items $\alpha = 0.89$, and "Science-related books," 13 items, $\alpha = 0.94$, asked how often teachers encouraged the use of magnifying glasses, magnets, binoculars and measuring tools, and nature, or read books with science, animals, bugs/spiders, plants/weather, space, dinosaurs, robots, building/home repair, and fairy tales. Questions were scripted with the form "Thinking back over the last month, how often do you *encourage* your students to use the following things?". Items were rated by respondents on a scale of "Never," (0) "Once or twice a week," (2) "Three to six times a week," or (3) "Every day" (4).

Retrospective outdoor activities

Items measuring retrospective outdoor activities were also adapted from The Home Science Interview (HSI; Van Egeren and Stein, 2012), specifically a portion focusing on "Community Science Resources," which included both indoor and outdoor formal science learning opportunities which teachers could report accessing over the last year. Four items specifically inquiring about outdoor trips like nature walks and trips to nature centers, parks, and gardens were scripted with the form "Thinking back over the last year, often do you take your students to the following types of field trips or out-of-school activities?". Items were rated by respondents on a scale of "Never," (0) "Once a year," (1), and

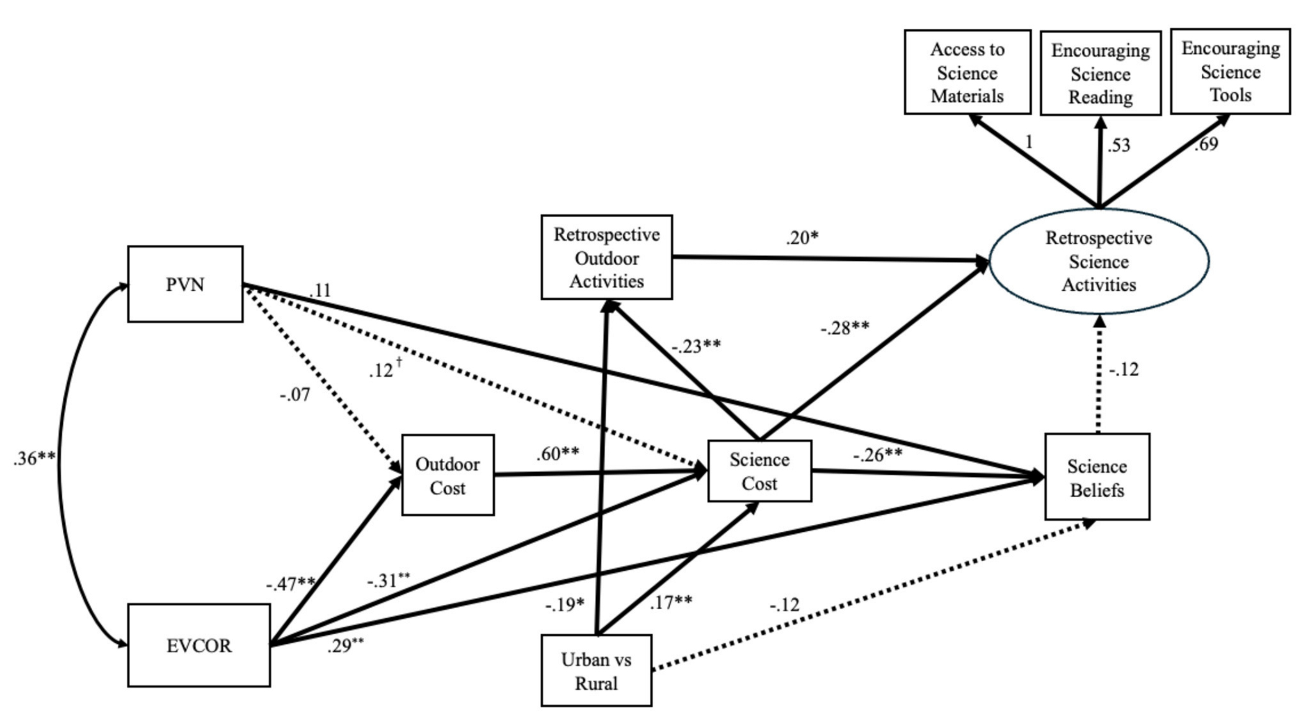

FIGURE 2
Structural equation model depicting the direct effects of intrinsic personal value for nature (PVN) and Expectations and Values Toward Children's Outdoor Recreation (EVCOR) on outdoor costs, science costs, and science beliefs, as differentially influenced by rurality. $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$.

"Twice a year or more" (2). Internal consistency for these items was $\alpha = 0.78$.

Definition of rural and urban

Respondents were asked to self-rate their community as rural (=0), suburban (=1), or urban (=2). For the analysis, urban and suburban areas collapsed and were coded as 1, while rural area were coded as 0. In the Qualtrics-administered survey, geolocation features were also used, which produced a latitude and longitude based on respondents' IP address. These coordinates were used to assign each respondent an NCES code, three of which are designated rural: 41 (rural, fringe), 42 (rural, distant), and 43 (rural, remote). Codes for towne (31, 32, 33), suburban (21, 22, 23), and city (11, 12, 13) function similarly. Given moderate agreement between respondents' self-identified rurality and their Qualtrics designation as having responded to coordinates classified as rural or town ($r = 0.34$), and that previous research indicates self-identifying as rural may better reflect participants' values and attachment to place (Nemerever and Rogers, 2021; Onega et al., 2020), we used self-identification in analyses.

Statistical analysis

Structural equation modeling was performed in the Stata 18.5 software (StataCorp, College Station, TX, USA). The full structural equation model (SEM) examined the direct paths from PVN and Expectations and Values Toward Children's Outdoor Recreation (EVCOR) to outdoor costs, science costs and science beliefs. A direct path was also fit from outdoor costs to science costs, from science costs to science beliefs and the latent construct of teacher retrospective reports of outdoor activities. The latent construct of retrospective reports of scientific activities was predicted by direct paths from retrospective reports of outdoor activities, science cost, science beliefs, and location (urban = 1 and rural = 0; see Figure 2). To leverage information from all data points, maximum likelihood with missing values estimation was used (Schafer and Graham, 2002).

A test of the total and indirect effect of location (urban vs. rural) on retrospective reports of scientific activities was also conducted using the estat command in Stata. This analysis was carried out for significant paths from location (urban vs. rural) with mediating variables (e.g., science cost, science beliefs, and retrospective reports of outdoor activities). Standard errors for mediated paths were obtained using the delta method (Bollen and Stine, 1990).

Results

Table one shows descriptive statistics and correlations between all study variables. The full SEM can be viewed in Figure 2. The main outcomes of interest were outdoor costs, science costs, science beliefs, and teacher retrospective reports of outdoor and scientific activities. Location (urban vs. rural) on outdoor cost, science cost, outdoor activities, and science beliefs were also explored.

Structural path model fit indices suggested good fit, χ^2 (22, N = 108) = 31.38, p = 0.089, comparative fit index = 0.97, Tucker–Lewis index = 0.94, root-mean-square error of approximation = 0.063. The path model showed that teachers' EVCOR scores were negatively related to outdoor cost ($\beta = -0.47$, $p < 0.01$), science costs ($\beta = -0.31$, $p < 0.01$), and positively related to science beliefs ($\beta = 0.29$, $p = <0.01$). This points to lower costs and higher science beliefs for teachers with higher values for children's outdoor recreation. Teachers PVN scores were unrelated to science beliefs, outdoor activities, and science costs.

A positive path was also found from outdoor cost to science cost ($\beta = 0.60$, $p < 0.01$). Science cost was negatively related to science beliefs ($\beta = -0.26$, $p < 0.01$), retrospective reports of outdoor activities ($\beta = -0.23$, $p < 0.01$), and retrospective reports of scientific activities ($\beta = -0.28$, $p < 0.01$). Additional positive paths were found from retrospective reports of outdoor activities to retrospective reports of scientific activities ($\beta = 0.20$, $p = 0.05$).

Location (urban vs. rural) differences were found for retrospective reports of outdoor activities ($\beta = -0.19$, $p = 0.03$) and science costs ($\beta = 0.17$, $p < 0.01$). These results suggest that teachers from rural areas reported more outdoor activities with their class and lower science costs. Location was not related to outdoor costs or retrospective reports of scientific activities.

Teachers' PVN scores were unrelated to outdoor and science costs, and outdoor cost scores were unrelated to reports of outdoor activities. Science beliefs were also unrelated to retrospective reports of scientific activities.

A test of the total effect of location (urban vs. rural) on retrospective reports of scientific activities through reports of outdoor activities and science costs were also conducted. The total effect of urban-rural differences on retrospective reports of scientific activities is a combination of the direct effect of reports of outdoor activities ($B = 0.27$, $p = 0.05$) and science costs ($B = -0.22$, $p = 0.01$) and the indirect effect of reports of outdoor activities and science cost and pointed to a stronger but non-significant total effect for rural teachers ($B = -0.12$, $p = 0.08$).

To further investigate the indirect relationship of location (urban vs. rural) on retrospective reports of scientific activities, mediation analyses were conducted for location (urban vs. rural) on retrospective reports of scientific activities through outdoor activities and science cost. Standard errors were obtained using the delta method (Bollen and Stine, 1990). The indirect path from urban-rural through outdoor activities was not significant ($B = -0.06$, $p = 0.10$), but the indirect path through science cost was statistically significant ($B = -0.09$, $p = 0.05$). Again, the negative coefficient suggests the indirect path of location (urban vs. rural) on scientific activities through science cost was stronger for rural teachers.

Discussion

The present study utilized the Situated Expectancy-Value Theory (SEVT, Eccles and Wigfield, 2020) to explore connections among teaching values and practices that are linked to outdoor science learning. Although 15%-30% of the preschool day is spent outdoors, limited research has explored factors, such as whether working within a rural context could be viewed as an asset to promoting outdoor science activities within ECE settings. Results in the present study showed that teachers' Expectations and Values Toward Children's Outdoor Recreation (EVCOR) were linked to outdoor costs, science costs, and science beliefs. Furthermore, teachers' intrinsic PVN was also linked to science beliefs, but not to outdoor costs or science costs. Teachers from rural areas showed lower science costs and higher science beliefs and reported they had participated in more outdoor activities with their class. Science costs and outdoor activities predicted teachers' retrospective reports of scientific activities, with science cost mediating (at trend) the path from location (urban vs. rural) to teachers' retrospective reports of scientific activities.

Our findings strengthen the rationale for a new conceptual model for early childhood educators' science teaching motivation that (a) incorporates outdoor learning and (b) draws on motivational theories more consistent with the literature on situated science learning and K-12 literature. Results point to a significant role for early educators' intrinsic outdoor values, expectancies, and comfort levels in supporting their perceptions and utility for children's outdoor and science learning, provision of science activities, and materials. For all early educators in this sample, the perceived costs associated with outdoor and science learning were related to their provision of science activities and materials. Rural teachers specifically showed higher self-reported retrospective outdoor practices and lower perceived science costs. This suggests that although rural teachers may have more barriers to doing science than their urban peers, it does not substantially impact their science practices and that outdoor experiences could be framed as an asset for the promotion of rural teachers' early science practices. This is not to suggest that significant investment in rural science access is not still necessary, but rather that heritage outdoor contexts may be an appropriate and relevant conduit through which to promote early science teaching and learning. Notably, additional training, technical assistance, and funding would be required to support teachers in maximizing science learning in outdoor spaces.

According to the present findings, teachers' intrinsic values for the outdoors and their expectancies and values for children's outdoor recreation play an important role in their perceived costs for both science beliefs, and how they utilize outdoor settings and science learning. This is consistent with prior research studies demonstrating that teachers' beliefs about outdoor learning influence their use of outdoor settings (Ernst, 2014) and that science beliefs influence engagement with science (Gerde et al., 2017). This is, however, to our knowledge, the first empirical research study that has ventured to investigate the structural relations between outdoor values, science beliefs, and science practices.

We also find strong support for the idea that teachers' intrinsic personal values, expectancies, and utility values for outdoor learning are separate constructs that relate to science costs and beliefs. For example, previous research (Gerde et al., 2017) found support for the idea that ECE teachers' science self-efficacy is related to their practices. Other research with older children has established a potential theoretical basis for how outdoor learning and science might link (Ayotte-Beaudet et al., 2021; Faber Taylor et al., 2022; Jackson et al., 2021). Our findings extend that research by explicitly including items about intrinsic personal and expectancies and utility values for outdoor learning *and relating* those to science beliefs and activities, which has not previously been done. Additionally, although previous research with families of young children (Zucker et al., 2022) has established a model for how parental expectancies and values around science learning relate to self-reported engagement with science, no studies that we are aware of has yet taken that motivational approach to ECE teachers' expectancies and values.

This study adds to the conversation about rural place-based strengths that can aid young learners and the adults who help them learn. Although prior research has established that the home learning environment is shaped by caregivers' geospatial residence (Eason et al., 2023; Myrtil et al., 2019; De Marco and Vernon-Feagans, 2013), less research to date has attended to how learning within out-of-home or center-based care may be shaped by teachers' location (urban vs. rural). Our findings in this study are consistent with an emerging theoretical and empirical body of research that strives to describe the cultural "wealth" of rural places (Crumb et al., 2023), including heritage, connections, and values around outdoor spaces and learning (Seaman et al., 2024).

Our findings that PVN and EVCOR relate to outdoor activities and science costs and that rural ECE teachers reported higher retrospective outdoor activities and lower science costs than their urban peers fill an important gap in the literature on ECE teachers' motivations and practices for doing science. Personal interest and enjoyment are essential drivers of teacher motivation for doing science, and teachers who have more heritage experience with the outdoor and natural world may be more motivated to engage in learning in those settings.

Limitations

We note some limitations to our findings. First, our sample draws only from one southeastern state, and 50% of our participants draw from the mountainous Appalachian region, which is generally more temperate and thus perceived as more amenable to outdoor learning than other parts of the country. Previous evidence in ECE has that ECE teachers may avoid outdoor activities in mild instances of inclement weather (heat, cold, and rain; Dankiw et al., 2023; Ernst, 2014; McClintic and Petty, 2015; Predy et al., 2021), and many ECE programs have become exposed to more extreme versions of those conditions than in the past (Grindal, n.d.). Additionally, there may be limitations in how rurality was measured (self-identified). However, in supplemental analyses, we found that self-identified rurality was still moderately correlated with NCES rural or town locale ($r = 0.34$).

Of note, a large portion of our respondents live and work in a mountainous region that can transition quite abruptly from pastoral farmland that has conventionally been considered "rural" to one of the fastest-growing metropolitan areas in the United States. Thus, although some of our respondents might live in more remote areas and be considered rural, if they responded to the survey while at their workstation, which may have better Internet access, broadband connectivity and cellular access than their rural or remote residence (Center for Public Education, 2023), this could inaccurately lead to their Qualtrics designation as being in a suburban area or city.

Finally, although some of the items in our survey map on well to the various components of SEVT, such as costs or utility values, more research is needed to elucidate how science teaching utility and attainment values are operationalized in a model of ECE teacher's values for teaching outdoor science. Attainment values are typically related to future achievement-oriented goals a student might have, although they have been described in some limited literature on older teachers (Jud et al., 2023, 2024). Utility values or perceived usefulness of practice have been more commonly described in ECE teachers' motivations for teaching science (Barenthien and Dunekacke, 2021) or engaging in science PD (Quesada-Pallarès et al., 2025). Although items indexing ECE teachers' attainment and utility values were included in the "science beliefs" construct predicting practices in our model, and fit well empirically, more research is needed to determine whether they should be modeled separately.

Future directions

Future studies should consider whether administrative, residential address of record and official workstation address rurality differ for rural early educators, and if those differences relate to their outdoor and science learning expectancies, costs, and values. Some studies have shown persistent incongruence in rural identity and geospatial markers of rurality and have indicated that self-identification as rural and the accompanying value systems matter more than external designations as such (Nemerever and Rogers, 2021; Onega et al., 2020).

Future analyses should also include in-depth analyses of qualitative responses regarding science activities that teachers are currently implementing in their classrooms and perceived needs related to science instruction in early childhood settings. This could offer a voice to the experiences of educators in the field and capture the nuances and complexities of the classroom environment, providing further context. Knowledge and understanding of early childhood educators' perceptions of high-quality science experiences and instruction in early childhood programming can facilitate the implementation of professional development and coaching and increase rigor and intentionality within early education programs.

Finally, future studies should explore whether teachers' outdoor and/or science beliefs and reported outdoor and/or science activities influence child learning and motivation for science. Prior evidence suggests that parental and teacher utility value for STEM has a "contagion" effect on children's utility value for and subsequent achievement in science (Nalipay et al., 2021). Work specifically with young children has shown that parental utility value for STEM positively predicts engagement with those activities during home learning (Zucker et al., 2022) and that training and coaching can improve the kinds of adult inquiry-promoting talk and practices (Chandler-Campbell et al., 2020; McWayne et al., 2022), which are associated with child outcomes.

Our findings represent an initial step to understanding the values of early childhood teachers hold regarding outdoor science learning and use that information to design and test meaningful interventions for improving science access and learning in ECE broadly, as well as in the rural communities that can leverage heritage connections to the outdoors.

Data availability statement

The datasets presented in this article are not readily available because the data used in this study contain sensitive personal information and cannot be publicly shared due to privacy concerns. Requests to access the datasets should be directed to spedonti@wcu.edu.

Ethics statement

This study involving humans was approved by the Western Carolina IRB. The study was conducted in accordance with local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SP: Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Writing – original draft, Writing – review & editing. DB: Data curation, Formal analysis, Methodology, Project administration, Writing – original draft, Writing – review & editing. MW: Writing – original draft, Writing – review & editing. CG: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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