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Social Psychology

The Role of Nature Cues and Nature Relatedness in Academic Motivation and Engagement

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Nature exposure in the form of immersion in natural environments can benefit students in multiple ways. Across four studies, we examined whether nature exposure in the form of visual nature cues on instructional materials might increase academic motivation and engagement among university students. Visual nature cues were presented via PowerPoint backgrounds (Study 1), online Zoom lecture backgrounds (Study 2), and on the background of calendars people used to plan for an upcoming assignment or exam (Studies 3 and 4). In each study and an internal meta-analysis, we found no evidence that nature cues increased academic engagement or motivation compared to other background images. However, participants' self-reported nature relatedness was linked to greater academic engagement and motivation in each study and the internal meta-analysis. The interaction between nature relatedness and nature exposure was not significant. We conclude that embedding visual nature cues in educational material is not sufficiently impactful to have an effect on academic motivation and that immersion and interaction with nature in a fuller sense may be necessary to reap motivational benefits.

Nature is known to have many positive effects on individuals' health, well-being, and cognition (e.g., Berman et al., 2012; Joye & Bolderdijk, 2015; see Capaldi et al., 2015 for a review). Nature exposure can also be beneficial in academic environments. There has been consistent interest from educators in forest schools in the past century, beginning with Danish schools for very young children (Dean, 2019). The idea of integrating educational settings with nature – teaching pupils outside rather than in a classroom – spread across countries and has been applied across a range of ages (e.g., Garden & Downes, 2023). Holding classes in nature has shown benefits for the pupils' well-being and motivation (Chou & Hung, 2021; Dopko et al., 2019; Karadag, 2019). Beyond exposure to nature in the moment, feeling generally more connected to nature has also been shown to link to a host of other benefits (Keaulana et al., 2021; Klootwijk et al., 2021; Lipowski et al., 2019). Nature exposure and nature relatedness might also provide motivational benefits in an academic context. In the present research, we examine whether less immersive nature exposure, such as visual nature cues in instructional materials, can also benefit students' motivation and engagement. Across four studies, we examine the role that visual nature cues and nature relatedness play in academic motivation and engagement in university students.

Nature's Role in Academia

Nature Exposure

Nature exposure has been linked with a number of psychological outcomes, which are in turn linked with academic outcomes: exposure to nature cues has been shown to restore attention (e.g., Moran, 2019; Stevenson et al., 2019), increase positive mood (e.g., Nisbet & Zelenski, 2011; Soga et al., 2021) and lower the body's stress response (e.g., Beukeboom et al., 2012; Ulrich et al., 1991). For example, mood among university students was more positive after taking a short walk outside rather than a short walk inside (Nisbet & Zelenski, 2011), and being able to view nature from one's window was linked to greater subjective happiness (Soga et al., 2021). Positive mood can enhance students' academic motivation (Klootwijk et al., 2021) or academic engagement (Ouweneel et al., 2011). Similarly, unchecked stress has been associated with lower academic performance (Sohail, 2013). Students with higher perceived stress were also less engaged in school and reported a reduced desire to persevere with academics (af

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Ursin et al., 2021). Thus, there is indirect evidence for the potential relevance of nature exposure to academic outcomes.

More direct support comes from research examining immersive nature exposure among students (Braun & Dierkes, 2017; Chawla et al., 2014; Dettweiler et al., 2015; Dillon et al., 2016; Dopko et al., 2019; Karadag, 2019; Khademi Ashkazeri & Mofradnejad, 2019; Lohr et al., 2021; Strong, 2019). Across different nature and outdoors programs, research has examined wellbeing in students and children's connection to nature as outcome variables (Braun & Dierkes, 2017; Dopko et al., 2019; Garden & Downes, 2023; Strong, 2019). A few of these studies also examined concepts related to motivation: Children who attended a nature school reported more motivation to learn than children in the same city who attended a traditional brick-and-mortar school (Khademi Ashkazeri & Mofradnejad, 2019), though this difference may have been due to other aspects about the school or school district. Three studies examined motivation-related outcomes in a within-subject design, tracking students who participated in nature programs. Among German pre-teens participating in an outdoor science teaching program, those who were lower self-regulated in traditional classes reported higher self-regulated learning in outdoor classes (Dettweiler et al., 2015). A qualitative study of social science university students found that students reported that holding classes about geography outdoors was motivating for class attendance (Karadag, 2019). A sample of 10 college students in China who were recruited to take 30-minute forest walks for eight weeks reported increased learning engagement and positive attitudes toward their college classes over time (Chou & Hung, 2021). Thus, there is correlational and qualitative evidence to suggest that integrating nature exposure can benefit students' engagement and motivation. However, there is limited support for causal links of nature exposure to academic outcomes, with only one of the studies on nature exposure in an academic context being experimental: Across two kindergarten classes, teachers varied whether the class was taught in a traditional indoor classroom or while exposed to nature in an outdoor classroom (Largo-Wight et al., 2018), showing that students required fewer redirection of disruptive or distracted behaviors in the nature classroom.

Nature exposure may mean physically spending time in a natural environment (Dopko et al., 2019), but it may also mean simply viewing images of nature. The benefits of nature cues have also been shown via printed photos of nature (Beukeboom et al., 2012; Brown et al., 2013), online images of nature (Joye & Bolderdijk, 2015; Yang et al., 2020), or even visual cues in the background of another picture (Dijkstra et al., 2008) or in a video (Palanica & Fossat, 2022). For example, Palanica and Fossat (2022) examined whether background images could influence creativity while video conferencing. They found that a greater amount and variety of detailed responses were given when the task was completed during a Zoom session with a nature background than a Zoom session with an urban background. Thus, even nature cues delivered via an online medium, such as video backgrounds, can have a measurable positive impact. Similarly, Dijkstra and colleagues (2008) found that participants viewing an image of a hospital room with indoor plants rather than an image of the same room with a picture with an urban scene instead of plants felt less stressed when imagining being a patient.

In the present research, we examine whether nature exposure in the form of visual nature cues in instructional material may show some of the same benefits as have been documented for more immersed nature exposure (e.g., Chou & Hung, 2021; Karadag, 2019; Largo-Wight et al., 2018; Strong, 2019). Nature images are easily integrated into PowerPoint, online lectures or other instructional materials, and if such images have a measurable effect on academic outcomes, these design choices by instructors might make a positive difference at little to no cost to the instructor.

Nature Connectedness

Individuals report feeling emotionally close to and experiencing the self as part of nature to varying degrees, and this feeling is reflected in the construct of nature relatedness (Mayer & Frantz, 2004; Nisbet et al., 2009). Greater nature relatedness might also benefit academic outcomes, independent of nature exposure. Meta-analyses (Keaulana et al., 2021; also see Capaldi et al., 2015; Nisbet et al., 2009; Pensini et al., 2016) of correlates of the Nature Relatedness scale (Nisbet et al., 2009; Nisbet & Zelenski, 2013) identified positive associations with self-reported health, well-being, hedonic and eudaimonic happiness, pro-environmental behavior, conscientiousness and openness, meaning in life, and negative associations with alcohol intake. Several of these correlates are also important predictors of academic outcomes: Academic motivation has been linked to greater well-being (e.g., Klootwijk et al., 2021; Ouweneel et al., 2011), greater conscientiousness (e.g., Komarraju et al., 2009; Werner et al., 2019), and less binge drinking (An et al., 2017). More directly, one study showed a positive association between nature connectedness and exercise motivation among individuals who practice karate - the more connected karate students felt to nature, the more motivated they were to exercise and be fit (Lipowski et al., 2019). To our knowledge, the link between nature connectedness and academic motivation or engagement in academic contexts has not been studied directly, but this indirect evidence suggests that – like nature exposure – nature relatedness benefits students' academic motivation.

In sum, nature connectedness may be linked with academic outcomes on its own or might interact with nature exposure: benefits of nature connectedness might only emerge when exposed to nature - or benefits of nature exposure might become stronger for those individuals who feel more related to nature. In the present studies, we examine the effect of visual nature cues, nature connectedness, and their interaction on academic outcomes.

Academic Outcomes

One of the most fundamental academic issues is students' positive attitude toward learning and their motivation to engage with the material, to learn and study. Academic engagement and motivation provide the necessary foundation for students to succeed. Students with high levels of academic motivation tend to obtain higher grades (Amrai et al., 2011; Fortier et al., 1995; Klootwijk et al., 2021), procrastinate less (Demir & Kutlu, 2018; Malkoç & Mutlu, 2018), and are less likely to drop out of school or university (Alivernini & Lucidi, 2011; Rump et al., 2017).

Just like any motivational construct, academic motivation is a complex construct with multiple aspects (e.g., Koenka, 2020; Osborne & Jones, 2011). For example, motivation may differ in *extent* of motivation as well as in *type* of motivation (e.g., self-determination theory, Deci & Ryan, 2008; see Howard et al., 2021 for a review in the academic context), may differ between motivation to achieve a specific outcome or motivation to follow a specific process (Osborne & Jones, 2011; Touré-Tillery & Fishbach, 2014), and may target the prevention of distractions/behaviors that are detrimental to achievement or target the promotion of studying/ behaviors that are instrumental to achievement (Lockwood et al., 2002).

In our research we focus on two aspects of extent of academic motivation. First, we examine the aspect of engagement that captures positive attitudes toward learning (Carmona-Halty et al., 2019), vigor or high levels of energy and mental resilience when studying, experiencing a sense of enthusiasm, and absorption or being fully engrossed in what one is studying. Second, we examine on the aspect of academic promotion motivation that captures intentions to study and work towards learning goals (Amrai et al., 2011; Lockwood et al., 2002; Osborne & Jones, 2011), making time to study and staying on track with academic assignments and reading. Thus, we assess both an emotional and a behavioral/intentional component of attitudes toward academic studies. Furthermore, we vary whether engagement and motivation is assessed as attitude towards all university classes, classes specific to the topic of the subject taught using nature cues, or the individual class that was linked with the nature-cue. Assessing two aspects of academic motivation and varying the target of motivation across studies should increase the generalizability of our conclusions.

Overview of the Present Research

Full immersion in a nature environment in an academic context has been linked to academic benefits (Chou & Hung, 2021; Dettweiler et al., 2015; Karadag, 2019; Khademi Ashkazeri & Mofradnejad, 2019). However, including full nature experiences in the classroom is a difficult feat. The main goal of the current studies was to examine if less immersive nature cues in educational experiences might also affect academic motivation and engagement positively. In other words, we extend on prior work by examining minimal nature cues embedded in educational materials among university students.

We examined the role of nature exposure and nature relatedness in academic engagement and motivation to study among university students across four online studies. Nature exposure was manipulated via visual cues presented as part of instructional materials. Specifically, participants viewed a PowerPoint presentation with a nature or indoor background (Study 1), viewed a Zoom lecture with a nature or indoor background (Study 2), and entered academic events on a calendar with a nature or urban background (Study 3 and 4). Studies 1, 2, and 3 were run simultaneously. Study 4 was run as a replication study for Study 3. As outcome variables, we assess academic engagement (Carmona-Halty et al., 2019) and academic motivation (Lockwood et al., 2002) in a variety of ways to capture several aspects: We assess academic engagement and motivation across all university classes and motivation for classes in the discipline of the instructional materials (Study 1), academic engagement and motivation for classes in the discipline of the instructional materials (Study 2), and academic engagement and motivation for a specific class they were engaging with in the materials (Study 3 and 4).

Across all studies, we expected that nature exposure and nature relatedness would independently be linked to more academic motivation and academic engagement, and that those who felt both connected to nature and had been exposed to nature cues would report the highest motivation and engagement. We report each study individually and then report the effects as an internal meta-analysis across the four studies.

Study 1

In this first study, nature exposure was manipulated via a PowerPoint background. University students viewed a PowerPoint presentation on a topic relating to one of their classes that featured either a background of images of forests or images of lecture halls. We expected that nature exposure and nature relatedness would be independently and additively linked to more academic motivation and academic engagement. The study was approved by a University Ethics Board prior to data collection. Data were analyzed only after all data was collected and is available in online supplements (https://osf.io/e7vy3/). All conditions but only pertinent measured variables are reported here; the unabbreviated survey is available in online supplements.

Methods

Participants

One hundred and ninety-five undergraduate students enrolled in introductory psychology were recruited to participate in a study titled "How Academically Motivated Are You?" and compensated with course credit. Ten participants were excluded because 1) the participant did not see the nature manipulation and/or did not complete the survey up until the final key variable in the study, the Nature Relatedness scale (n = 4) and/or 2) the participant failed the recall manipulation check (n = 6). The final sample size of 185 participants has 80% power to detect medium-sized

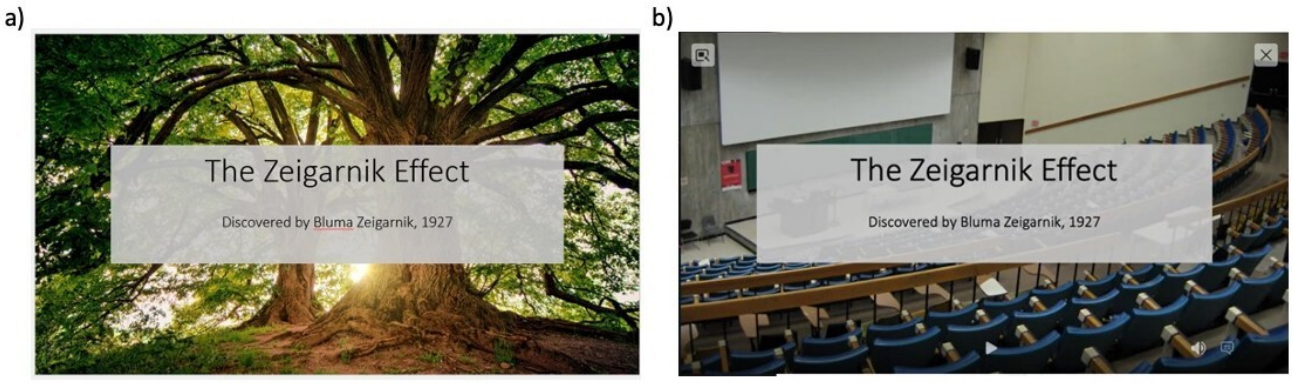

Figure 1. Example backgrounds of the PowerPoint: a) nature condition, b) control condition.

effects (d = 0.4) in comparing two conditions. The sample consisted of 136 females (73.5%), 48 males (25.9%), and one non-binary individual (0.5%). The average age of participants was 19.24 (SD = 3.31). A larger percent of the sample identified their ethnicity as White/Caucasian (49.1%) and Asian (15.5%). A smaller percentage of participants identified as mixed ethnicity (7%), Indigenous (5.9%), Black/African-Canadian (3.2%), Hispanic (1.1%), or did not respond to the question (8.1%).

Procedures

In this online study, after consenting, participants answered demographic questions (age, gender, ethnicity, year of study, and major). Next, participants were randomly assigned to view one of two three-minute videos of a PowerPoint presentation with a voice-over about a psychological phenomenon - the Zeigarnick effect. The presentation either showed backgrounds of natural environments (with six different images of trees and forests; n = 96) or classroom environments (with six different images of classrooms and lecture halls; n = 89; see Figure 1). The image backgrounds, both natural and of the classroom, were chosen from a database of royalty-free images online. The forest images were chosen for their inclusion of trees and forests, which are identified as more essential environments representative of the definitions of nature (Van den Berg et al., 2014).

After watching the presentation, participants filled out the Academic Engagement Scale (Carmona-Halty et al., 2019), the Academic Motivation Scale (Lockwood et al., 2002), and the brief Nature Relatedness scale (Nisbet & Zelenski, 2013). Lastly, in a manipulation check testing accurate recall, participants were asked to describe the background of the PowerPoint presentation. Participants were identified as failing the manipulation check if they gave an incorrect response to the recall manipulation check.

Measures

Academic Engagement. Academic engagement was measured with Carmona-Halty et al.'s (2019) Utrecht Work Engagement Scale for students (UWES-9S). This 9-item scale asked participants to indicate how often they felt a range of feelings about engagement towards their academic courses (e.g., "I am enthusiastic about my studies.") on scales from *never* (0) to *always* (6). Items were averaged (Cronbach's $\propto$ = .89). One value was above or below three standard deviations from the mean and was excluded from analyses (i.e., coded as 'missing') to prevent these values from biasing results.

Academic Motivation. Participants rated the seven items assessing positive study motivation from Lockwood and colleagues' (2002) Academic Motivation Scale (e.g., "I plan to study harder for my tests and exams") on scales from *not at all true (1) to very true (11)*. Items were averaged ($\propto$ = .95). In addition, participants completed an adapted Academic Motivation Scale assessing their positive study motivation for their psychology classes in particular (e.g., "I plan to study harder for my tests and exams in my psychology courses") on scales from *not at all true (1) to very true (11)*. Items were averaged ($\propto$ = .93). Four (two for the academic motivation and two for the updated academic motivation) values were above or below three standard deviations from the mean and were excluded from analyses.

Nature Relatedness. The brief Nature Relatedness scale (Nisbet & Zelenski, 2013) was used to measure nature relatedness (e.g., "My relationship to nature is an important part of who I am."). This 6-item scale asks participants to rate their agreement on statements on a scale from *strongly disagree* (1) to *strongly agree* (5). Items were averaged (Cronbach's $\propto$ = .83). No values were above or below three standard deviations from the mean.

Results and Discussion

Table 1 presents academic outcome means by condition. Stepwise hierarchical regression analyses were run regressing academic outcomes on the nature exposure condition and nature relatedness in the first step and on the condition by nature relatedness interaction term in the second step. This stepwise hierarchical regression format will allow us to explore the main effects outside of the influence of the interaction effect. The interaction term was created by multiplying the nature manipulation condition (coded as 0 – Classroom and 1 – Nature) and a grand mean-centered nature relatedness (i.e. a participant's score is subtracted by the mean value of nature relatedness).

Table 1. Academic Engagement and Motivation by Nature Exposure Condition across all studies.

	Nature Exposure Condition			
	Nature		Control	
	M	*SD*	*M*	*SD*
Study 1				
Engagement	3.03	0.78	3.24	0.83
Motivation	9.09	1.66	9.34	1.53
Motivation (discipline-specific)	8.71	1.83	9.05	1.53
Study 2				
Engagement	2.78	0.74	2.75	0.83
Motivation	8.39	1.83	8.78	1.67
Study 3				
Engagement (course specific)	3.38	1.12	3.29	1.27
Motivation (course specific)	8.18	2.13	8.19	2.08
Study 4				
Engagement (course specific)	2.20	1.19	2.29	1.26
Motivation (course specific)	7.98	1.61	7.87	1.66

Note. Engagement was measured on a 7-point scale; Academic Motivation was measured on a 11-point scale. Study 3 aggregates across event conditions.

First, academic engagement was examined as the outcome variable. Only nature relatedness was a significant predictor, b = 0.31, SE = 0.07, $t(180) = 4.69$, $p < .001$ 95% CI [0.18, 0.44]; the nature exposure condition was not a significant predictor, b = -0.18, SE = 0.11, $t(180) = -1.61$, $p = .11$, 95% CI [-0.41, 0.04], and neither was the interaction, b = -0.11, SE = 0.13 $t(179) = -0.80$, $p = .43$, 95% CI [-0.37, 0.16].

Next, academic motivation was examined as the outcome variable. Neither nature relatedness, b = 0.23, SE = 0.14 $t(178) = 1.68$, $p = .10$, 95% CI [-0.04, 0.51], nor nature exposure condition, b = -0.23, SE = 0.24 $t(178) = -0.96$, p = .34, 95% CI [-0.70, 0.24], were significant predictors of academic motivation. Additionally, the interaction between nature relatedness and nature exposure condition was also not significant, b = 0.09, SE = 0.28 $t(177) = 0.33$, $p = .75$, 95% CI [-0.46, 0.64].

Lastly, academic motivation for psychology-specific courses was examined as the outcome variable. Similarly to academic engagement, only nature relatedness was a significant predictor, b = 0.45, SE = 0.14, $t(180) = 3.15$, p = .002 95% CI [0.17, 0.73], whereas the nature exposure condition was not, b = -0.29, SE = 0.25, $t(180) = -1.19$, $p = .24$, 95% CI [-0.78, 0.19]. The interaction was also not a significant predictor of academic motivation for psychology-specific courses, b = 0.22, SE = 0.29 $t(179) = 0.78$, $p = .44$, 95% CI [-0.34, 0.79].

Overall, the results from Study 1 suggest that there was no effect of exposure to visual cues of forests and trees (vs. classrooms) during a PowerPoint on academic engagement and academic motivation[1]. There was, however, some suggestion that nature relatedness impacts feelings of academic engagement and motivation.

Study 2

In this second study, nature exposure was manipulated via a Zoom lecture background. Arguably, a Zoom lecture is more engaging than PowerPoint slides alone and might garner more attention to the lecture and, along with it, the background. University students viewed a Zoom lecture on a topic relating to one of their classes that featured either a background image of a lake and trees or a background image of a lecture hall. We again tested whether nature exposure and nature relatedness would be independently and additively linked to more academic motivation and academic engagement. The study was approved by a University Ethics Board prior to data collection. Data were analyzed only after all data was collected and is available in online supplements (https://osf.io/e7vy3/). All conditions but only pertinent measured variables are reported here. The unabbreviated survey is available in online supplements.

Methods

Participants

Two hundred undergraduate students currently enrolled in introductory psychology were recruited to participate in a study titled "Exploring Students Academic Interests and Motivation; Learn about Happiness!" and compensated with course credit. Fourteen participants were excluded because 1) they did not see the nature manipulation and/or

1 Results of additional analyses did not indicate that mood mediated the effect of nature cues on academic motivation and engagement. Thus, the measure was dropped in later studies. To see these results in further details, see OSF (https://osf.io/ryp3j)

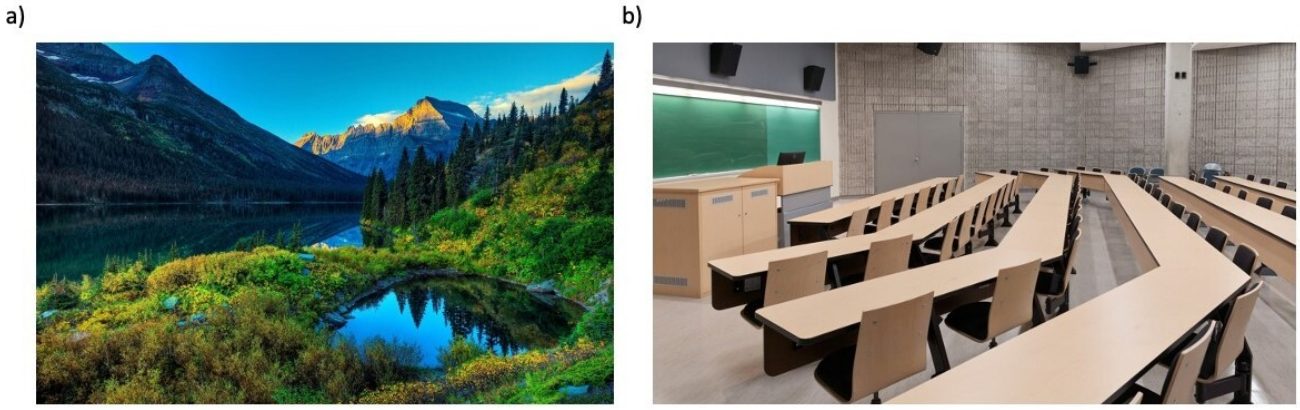

Figure 2. Background image of the Zoom lecture: a) nature condition, b) control condition.

did not complete the survey up to the Nature Relatedness scale (n = 7) and/or 2) failed the recall manipulation check (n = 7). The final sample size of 186 participants has 80% power to detect medium-sized effects (d = 0.4) in comparing two conditions. The sample consisted of 126 women (67.1%), 56 men (30.1%), three identified as another gender (1.6%), and one preferred not to disclose their gender (0.5%). The average age of participants was 19.30 (SD = 2.98). A larger percentage of the sample identified their ethnicity as White/Caucasian (51.1%) and Asian (20.4%). A smaller percentage of participants identified as Black/African-Canadian (9.7%), Middle Eastern (8.6%), Hispanic (2.2%), Indigenous (1.1%), other (1.6%), or mixed ethnicity (5.4%).

Procedures

In this online study, after consenting to the study, participants answered demographic questions (age, gender, ethnicity, year of study, and major). Next, participants were randomly assigned to view one of two two-minute videos of a short Zoom lecture on the definition of happiness. The lecture either featured a nature background (n = 90) or a classroom background (n = 96; see Figure 2). Similarly to Study 1, the image backgrounds were selected from an online database of royalty-free images and the nature image was chosen as it captures three elements that are often seen as representative of definitions of nature: lakes, forests, and mountains (Van den Berg et al., 2014).

After watching the video, participants filled out the Academic Engagement (Carmona-Halty et al., 2019; $\propto$ = .87), the Academic Motivation Scale (Lockwood et al., 2002; $\propto$ = .94) regarding their engagement and motivation towards all their psychology classes, and the short Nature Relatedness scale (Nisbet & Zelenski, 2013; $\propto$ = .86), as in Study 1. Values above or below three standard deviations from the mean were excluded from analyses to prevent these values from biasing results (engagement n = 3, motivation n = 2, nature relatedness n = 0). Lastly, in a manipulation check testing accurate recall, participants were asked to describe the background of the Zoom video. Participants were identified as failing the recall manipulation check if they provided an incorrect answer.

Results and Discussion

Table 1 presents academic outcome means by condition. Stepwise hierarchical regression analyses were run regressing academic outcomes on the nature exposure condition and nature relatedness in the first step and on the condition by nature relatedness interaction term in the second step. Similar to Study 1, the interaction term was computed by multiplying the nature exposure condition (coded as 0 – classroom and 1 – nature) by the mean-centered nature relatedness.

First, academic engagement was examined as the outcome variable. Only nature relatedness was a significant predictor, b = 0.17, SE = 0.06 t(181) = 2.67, p = .01, 95%CI [0.44, 0.29], whereas the nature exposure condition was not, b = 0.02, SE = 0.12 t(181) = 0.14, p = .89, 95%CI [-0.21, 0.24]. The interaction was not a significant predictor of academic engagement, b = -0.10, SE = 0.13 t(178) = -0.80, p = .43, 95%CI [-0.35, 0.15].

Second, academic motivation was examined as the outcome variable. Similarly, only nature relatedness was a significant predictor, b = 0.37, SE = 0.14 t(180) = 2.72, p = .01, 95%CI [0.10, 0.64], whereas the nature exposure condition was not, b = -0.41, SE = 0.26 t(180) = -1.59, p = .11, 95%CI [-0.91, 0.10]. The interaction was also not a significant unique predictor of academic motivation, b = 0.33, SE = 0.28 t(179) = 1.19, p = .24, 95%CI [-0.22, 0.87].

Similar to Study 1, the results of Study 2 suggest that nature exposure did not impact academic engagement and motivation, but nature relatedness did.

Study 3

In this third study, nature exposure was manipulated in a way that was designed to engage participants more actively. Rather than watching a PowerPoint or a lecture, university students were asked to think of a real event in their lives and to enter it on a digital calendar. The calendar either featured a nature background of a mountain range or an urban background of a skyline. Thus, the control images were also in an outdoor setting but in an urban, built environment. It is possible that the better 'fit' of spaces associated with learning (classrooms) motivated participants

in Study 1 and 2 as much as the pictures of nature. Urban outdoor spaces are a common control group in studies examining the effect of visual nature cues (e.g., Brown et al., 2013; Dijkstra et al., 2008; Palanica & Fossat, 2022; Yang et al., 2020). We again examined whether nature exposure and nature relatedness would be independently and additively linked to more academic motivation and academic engagement. In addition to the nature exposure condition, we varied whether the nominated event was academic or non-academic to explore whether activating topic relevance while being exposed to nature cues increases the hypothesized nature exposure effect. The study was approved by a University Ethics Board prior to data collection. Data were only analyzed after all data was collected and is available in online supplements (https://osf.io/e7vy3/). All conditions but only pertinent measured variables are reported here. The unabbreviated survey is available in online supplements.

Methods

Participants

A sample of 300 participants, all of whom were undergraduate students enrolled in an introductory psychology course, were recruited for a study called "Tell us about your study plans" and compensated with course credit. The study was run in the Fall term of 2021. Twenty-one participants were excluded because 1) the participant did not complete the study (n = 6) and/or 2) failed the recall manipulation check outright (n = 15), resulting in a final sample of 277 participants. This sample size has 80% power to detect small to medium-sized effects (d = 0.3) in a comparison of two conditions. The sample consisted of 207 females (74.7%), 63 males (22.7%), and seven non-binary individuals (2.5%). The average age of participants was 19.42 (SD = 3.83). A larger percent of the sample identified their ethnicity as White/Caucasian (49.1%), Asian (15.5%), A smaller percentage of participants identified as Black/African-Canadian (9.4%), mixed ethnicity (9.7%), Middle Eastern (6.1%), Hispanic (2.9%), Indigenous (2.5%), other (2.9%), or did not respond to the question (1.8%).

Procedures

In this online study, after consenting, participants completed a demographics questionnaire (age, gender, ethnicity, major, and number of classes currently taking). Participants were randomly assigned to either think of and describe an upcoming event in their introductory psychology class (e.g., a midterm) or an upcoming hobby event (e.g., a sports game). The digital calendar either had a nature background (n = 155) or an urban background (n = 122; Figure 3). The images used in the background of the calendars were selected from a database of royalty-free images online and matched in terms of color palette.

Next, participants were asked to interact with the calendar; specifically, they were asked to make an action plan of three things they planned to do in preparation for the event. They were, again, given the same calendar as previously seen (nature or urban background) to select the three dates they will perform the actions mentioned in their plan on the calendar and describe the action plan. Thus, participants saw the calendar with either a nature or an urban picture twice.

They, then, reported their Academic Engagement (Carmona-Halty et al., 2019, $\propto$ = .92) adapted to ask about engagement with regards to their introductory psychology class (e.g., "I currently feel enthusiastic about PSYC1000") and their Academic Motivation (Lockwood et al., 2002, $\propto$ = .92), adapted to ask about motivation with regards to their introductory psychology class (e.g., "Right now, I plan to put extra effort into the rest of my assignments for PSYC1000"). Values above or below three standard deviations from the mean were excluded from analyses to prevent these values from biasing results (engagement n = 1, motivation n = 1).

A single item was used to measure nature relatedness ("I feel very connected to nature"), on a scale from *disagree strongly* (1) to *agree strongly* (5). No outliers were found for this item.

Lastly, participants completed a recall manipulation check, where they were asked to describe the calendar background they previously saw in their own words. Participants were identified as failing the recall manipulation check if they provided an incorrect description.

Results and Discussion

First, we examined whether having an academic or nonacademic event on one's mind while interacting with the calendar mattered. A two (event: hobby, event) by two (nature exposure condition: nature, urban) ANOVA showed no significant main effect of event condition on academic engagement, $F(1, 272) = 0.50$, $p = .48$, $\eta_p^2 = 0.002$, or academic motivation, $F(1, 272) = 1.01$, $p = .32$, $\eta_p^2 = 0.004$. The interaction between the two conditions was also not significant for academic engagement, $F(1, 272) = 3.35$, $p = .07$, $\eta_p^2 = 0.01$, or motivation, $F(1, 272) = 0.90{,}2$ $p = .34$, $\eta_p^2 = 0.003$. We thus aggregated the data across the event condition for further analyses.

Next, two hierarchical regressions were run to examine the role of nature exposure and nature relatedness as predictors, across event conditions. Table 1 presents the outcome means by nature exposure condition. The main effect of nature exposure condition (coded as 0 – Urban and 1 – Nature) and nature relatedness (mean-centered) were included in the first model. The interaction effect (computed by multiplying the nature exposure condition by the mean-centered nature relatedness score) was included in the second model.

The nature exposure condition did not significantly predict academic engagement, b = 0.10, SE = 0.14, $t(273) = 0.71$, p = .48, 95%CI [-0.18, 0.38]. Nature relatedness was, however, a significant predictor, b = 0.15, SE = 0.06, $t(273)$ = 2.38, p = .02, 95%CI [0.03, 0.27]. The interaction between the nature exposure condition and nature relatedness was not a significant predictor of academic engagement, b = -0.10, SE = 0.12, $t(272) = -0.82$, p = .41, 95%CI [-0.35, 0.14].

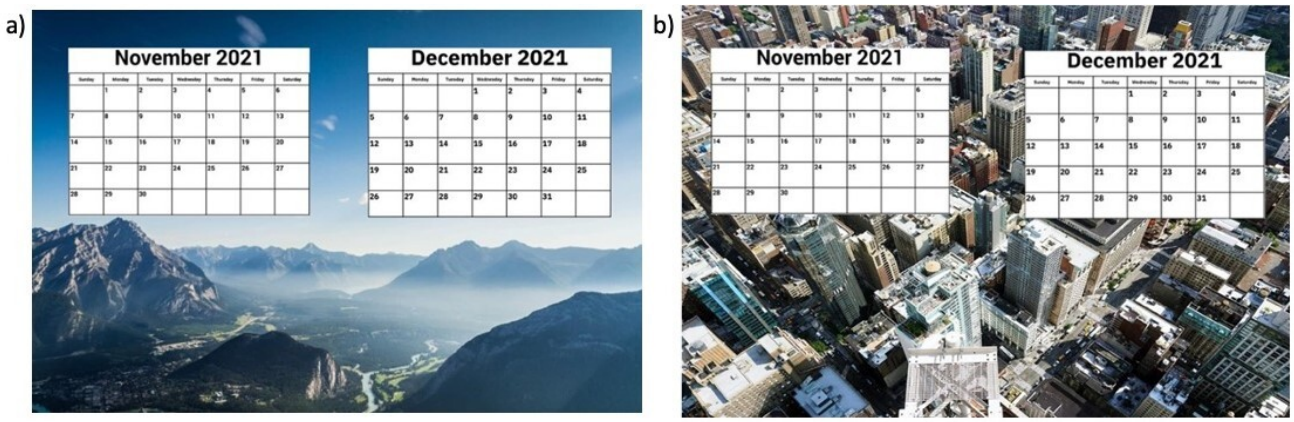

Figure 3. Backgrounds of the calendar: a) nature condition, b) control condition.

In regards to academic motivation, neither nature relatedness, b = 0.13, SE = 0.11, $t(273)$ = 1.21, p = .23, 95%CI [-0.08, 0.35], the nature exposure condition, b = 0.001, SE = 0.26 $t(273)$ = 0.002, p = .99, 95%CI [-0.50, 0.50] nor the interaction, b = -0.08, SE = 0.22, $t(272)$ = -0.36, p = .72, 95%CI [-0.52, 0.36] were predictors of motivation to study in the class.

Thus, nature exposure in a more interactive context while calling to mind an actual event in students' lives did not influence academic engagement and motivation. Nature-relatedness was again a significant predictor of engagement, but not motivation. However, this study was limited by only using an individual image as the calendar background, which may not have been seen as representative of nature by all participants (i.e., relatively little green tones). Secondly, by varying the event type, the power to detect events in just the relevant academic event condition might have been limited. Lastly, while academic events abound in a university student's life, there might not have been a suitable event in their psychology classes in the timeframe of the calendar.

Study 4

In the final study, we replicated Study 3 with a larger sample and with all participants planning for an academic event on the calendar. University students were asked to think of an academic event in any one of their classes and to enter this event on a digital calendar that featured a variety of nature or urban scenes as backgrounds. In the previous studies, the natural stimuli were selected as representative of general definitions of nature (Van den Berg et al., 2014). For Study 4, additional considerations were taken when selecting the images. For one, rather than choosing one image for each condition as in the previous study, we randomized five different nature images and five different control (urban) images between participants. Second, previous research has shown that the features of natural scenery can matter (e.g., mountains and forests represent nature, but can affect mood differently, Chiang et al., 2017; Van den Berg et al., 2014). Thus, the images used in the background of the digital calendars for this study had a wider range of different types of nature environments than only forests and mountains as used in previous studies. The images selected for this study were previously used by Meidenbauer et al (2020). These images are considered equally attractive images for both natural and urban environments (Meidenbauer et al., 2020). Notably, these images did not show different boosts in affective states; thus, this current study did not measure mood.

Moreover, researchers have suggested that one should not make generalized assumptions for a single stimulus, but rather explore effects across a range of stimuli (Judd et al., 2012; Wells & Windschitl, 1999). Therefore, with the randomized images used in the digital calendars' background, we were able to explore if the effect of nature condition may be affected by individual stimuli rather than the categorization of natural and urban environments. This aspect of the methodology was intended to extend the generalizability.

We again examined whether nature exposure and nature relatedness would be independently and additively linked to more academic motivation and academic engagement. The study was approved by a University Ethics Board prior to data collection. Data were analyzed after all data was collected and is available in online supplements (https://osf.io/e7vy3/). All conditions but only pertinent measured variables are reported here. The unabbreviated survey is available in online supplements.

Method

Participants

Six hundred and ten undergraduate students were recruited for a study called "Tell us about your study plans" and compensated with course credit. Data were collected

during the 2022 spring and summer semesters and the 2023 winter semester.[2] A total of 65 participants were excluded for the following reasons: 1) they did not complete the study (n = 18) and/or 2) they failed the recall manipulation check outright (n = 44), resulting in a final sample of 545 participants. This sample size has 80% power to detect small-sized effects (d = 0.2) in a comparison of two conditions. This final sample consisted of 422 females (77.4%), 115 males (21.1%), and eight non-binary individuals (1.5%). The average age was 20.78 (SD = 4.44). A large portion of the sample identified as white/Caucasian (46.1%), Asian (18.9%), and Black/African-Canadian (10.8%). A smaller percentage of the sample identified as mixed ethnicity (9.2%), Middle Eastern (7.7%), Hispanic (2.0%), Indigenous (1.7%), other (1.7%), or did not respond (2.0%).

Procedure

In this online study, after consenting, the participants were asked demographic information (age, gender, ethnicity, and major). As in the academic event condition in Study 3, participants were asked to think about an event or assignment that would be occurring in one of their current classes. The participants had to describe the event and identify the class for the event. Next, the participants were randomly assigned to see one of ten digital calendars with different background images (Meidenbauer et al., 2020). Five calendars had a nature background depicting a forest, a lake, a mountain, a flowering meadow, and a forest clearing, respectively (n = 283), whereas the other five had an urban background depicting an antique building, a skyscraper skyline by day, a skyline by night, a street of tall rows of houses, and a street brick housefronts, respectively (n = 262). Pictures were approximately matched in the degree of colourfulness and level of detail. As in Study 3, participants interacted with the calendar by clicking on it to identify the time of the event and then entered an action plan to prepare for the event on the calendar.

Following the experiment portion, participants were asked to fill out outcome variables, such as academic motivation (Lockwood et al., 2002; Cronbach's $\propto$= .88) adapted to ask about motivation for the class they nominated, engagement (Carmona-Halty et al., 2019; Cronbach's $\propto$= .92) adapted to ask about engagement for the class they nominated, and the 6-item Nature Relatedness scale (Nisbet & Zelenski, 2013; Cronbach's $\propto$= .84) Values above or below three standard deviations from the mean were excluded from analyses to prevent these values from biasing results (engagement n = 1, motivation n = 4, nature relatedness n = 0). Lastly, participants completed a recall manipulation check as in previous studies. To fail the recall manipulation check, participants needed to give an incorrect answer to the question.[3]

Results and Discussion

Table 1 presents academic outcome means by condition. Stepwise hierarchical regression analyses were run regressing academic outcomes on the nature exposure condition and nature relatedness in the first step and on the condition by nature relatedness interaction term (nature exposure condition × mean-centered nature relatedness) in the second step.

For academic engagement, the nature exposure condition was not a significant predictor, b = -0.09, SE = 0.10, t(539) = -0.83, p = .41, 95%CI [-0.29, 0.12]; however, nature relatedness was, b = 0.15, SE = 0.06, t(539) = 2.57, p = .01, 95%CI [0.04, 0.26]. The interaction was not a significant predictor of academic engagement, b = -0.08, SE = 0.12, t(538) = -0.69, p = .49, 95%CI [-0.31, 0.15].

For academic motivation, the nature exposure condition was not a significant predictor, b = 0.11, SE = 0.14, t(536) = 0.75, p = .45, 95%CI [-0.17, 0.38], but nature relatedness was, b = 0.16, SE = 0.08, t(536) = 2.10, p = .04, 95%CI [0.01, 0.32]. The interaction between the two variables was not a significant predictor of academic motivation, b = -0.13, SE = 0.16, t(535) = -0.82, p = .41, 95%CI [-0.43, 0.18].

To examine whether the types of nature or urban scenes mattered, the hierarchal regressions were also run as multilevel models with the data nested within the individual stimuli (i.e. the 10 individual pictures). The results above were unchanged, and the random effect of the individual pictures was either non-significant (for academic engagement) or too small to converge the model (for academic motivation). A full description of the results from these models can be seen on OSF (https://osf.io/k9fr2).

Together, the results suggest, again, that nature exposure did not influence academic engagement and motivation, regardless of the different types of natural environments presented in background images and the choice of classes for the academic event. However, those participants higher in nature relatedness reported more academic engagement and motivation.

Internal Meta-analysis

The pattern of results across four studies revealed consistent patterns of no nature exposure condition main effect, a positive nature relatedness main effect, and no in-

2 We initially recruited a sample of 300 participants in the spring and summer term. We recruited a second sample of 310 participants to rule out that any null effects were produced by less attentive responding from participants from the spring and summer pool compared to participants recruited in the regular university year (i.e., Fall and Winter term). Study design was identical between samples (other than the calendars themselves being updated to reflect the current months) and they are combined for ease of presentation. Results are unchanged if analyzed separately for the two samples or if adding the data collection sample variable as covariate.

3 In this study we also included a separate recognition manipulation check where participants selected the image they saw earlier as calendar background out of all the possible options (i.e., all ten calendar backgrounds). Exploratory analyses considering only those participants who passed both the recall and the recognition manipulation check (n = 548) replicate results reported below.

Table 2. Effect of nature exposure condition, nature relatedness, and their interaction term on academic engagement and academic motivation across studies

			Nature Exposure Condition		Nature Relatedness		Condition X Nature Relatedness	
Outcome	Study	*N*	*d*	η^2_p	*d*	η^2_p	*d*	η^2_p
Engagement	1	185	0.201	0.01	0.703	0.11	0.127	0.004
	2	186	0.006	0.00001	0.408	0.04	0.090	0.002
	3	277	0.090	0.002	0.667	0.1	0.016	0.0001
	4	545	0.035	0.0003	0.201	0.01	0.028	0.0002
		avg d	0.07		0.41		0.05	
		Z	1.18		7.03**		0.87	
Motivation	1	185	0.201	0.01	0.286	0.02	0.063	0.001
	2	186	0.201	0.01	0.408	0.04	0.127	0.004
	3	277	0.020	0.0001	0.127	0.004	0.028	0.0002
	4	545	0.063	0.001	0.201	0.01	0.040	0.0004
		avg d	0.10		0.23		0.05	
		Z	1.66		3.93**		0.94	

Note. ** $p < .01$. Engagement measured on a 7-pt scale, Motivation measured on a 11-pt scale. Nature relatedness measured on a 5-pt scale. Main effects were obtained without interaction terms in the model. Interaction controlled for main effects. In Study 1, we only included one of the two academic motivation scales (the original scale rather than the adapted scale) to weigh every sample's effect only once.

teraction effect. To further summarize and evaluate results across studies, we conducted an internal mini-meta-analysis (Goh et al., 2016). We converted η^2_p values of estimated marginal means analysis into *d*, which we then used as the basis of the meta-analysis (see Table 2). Across all studies, nature exposure did not affect academic engagement or academic motivation. Nature relatedness was significantly associated with academic engagement and academic motivation, with a medium and a small effect size, respectively. The exposure × relatedness interaction was nonsignificant overall.

General Discussion

Nature exposure and nature relatedness have been linked to a number of benefits (Berman et al., 2012; Joye & Bolderdijk, 2015; see Capaldi et al., 2015 for a review), including greater academic engagement and motivation in an educational context. To date, evidence from nature exposure benefits in an educational setting has focused on full immersion in forest schools or outdoor classrooms (e.g., Chou & Hung, 2021; Dopko et al., 2019; Karadag, 2019; Khademi Ashkazeri & Mofradnejad, 2019). The present research examined whether more minimal nature exposure – visual cues integrated into educational materials – can also benefit academic motivation among university students. Across four studies examining different types of visual nature cues and two academic outcome variables, we found no evidence that visual cues of nature increased academic engagement or academic motivation compared to visual cues of classroom (Studies 1 and 2) or urban settings (Studies 3 and 4). However, we did find that those students who reported feeling more connected with nature also reported higher academic motivation and engagement with their university classes, regardless of nature exposure, in each study. Thus, our studies underline the relevance of nature in an educational context, but also suggest that exposure to nature via small visual cues is not a sufficiently immersive or intense experience to matter noticeably.

Implications

Although there was no clear benefit of nature cues added to academic materials in the current studies, there is previous evidence that minimal nature exposure, such as visual-only cues (Brown et al., 2013; Joye & Bolderdijk, 2015; Yang et al., 2020) or even just visual cues in the background of another media (Dijkstra et al., 2008; Palanica & Fossat, 2022) can have meaningful effects. There is also evidence that the degree of immersion in nature does matter for the size of effect nature exposure might have, for both real and virtual exposure (Braun & Dierkes, 2017; Li et al., 2023; Ojala et al., 2022). In a study exploring how varying degrees of immersion (only nature sounds, only a nature video, or both sound and video) with short virtual nature breaks in an office may impact restoration, all virtual nature decreased feelings of stress, but the virtual nature with the most immersion (using both video and audio of nature) was the best at increasing feeling of restoration (Ojala et al., 2022). Most relevant to the current study, Braun and Dierkes (2017) showed that the intensity of nature experience (measured through the length of exposure) influenced the success of outdoor education programs: When primary and secondary students were exposed to either a single or five days of outdoor education, the longer intervention was better at promoting and sustaining nature connection. The studies presented here suggest that visual nature cues do not substitute full nature immersion. It is possible that visual cues alone can have an effect if they are more obvious and salient, for example, when integrated into the physical

environment rather than the instructional materials: students in a classroom with forest wall decals might experience this nature exposure to greater effect than students in our studies.

Limitations

Although we examined different types of educational materials (PowerPoint presentations, Zoom lectures, and calendars for planning assignments), the range of materials we examined was limited. It is possible that nature cues are more impactful when presented in different educational materials. For example, visual cues might also be presented in the background of an online course page or the background of in-person lectures. Relatedly, the length of exposure to cues was short (three minutes in Studies 1 and 2; 1-3 minutes in Studies 3 and 4), and we do not rule out that longer exposure might produce an effect. It is important to note that all participants included in these studies did notice the visual cues, as those who failed the recall manipulation check were excluded. Thus, it does not seem to be the case that the exposure length was outside the range of awareness. Furthermore, the studies were adequately powered to detect small to medium effects, and the number of participants across all studies in the internal meta-analysis included 1,193 unique participants.

Important to consider is also the limited range of nature cues we examined. Nature has been defined in many different ways (Fehnker et al., 2021; Hartig & Kahn, 2016), and perhaps the visual cues we chose (involving forests, flowering meadows, mountains, and lakes) are less impactful than other cues could have been. However, across studies examining different definitions of nature, the theme that emerges the most is that nature is distinct and unaltered by humans (Haluza-DeLay, 2001; Pointon, 2013; Vining et al., 2008). The natural stimuli used in all four studies fit this description. Additionally, across the four studies, a range of different stimuli were used, and Study 4 randomized the stimuli showing that the individual stimuli did not affect the academic outcomes. This suggests that the null effect generalized across a multitude of natural environment cues. Regarding the visual cues in the control groups, it is important to note that stimuli varied between indoor classroom images in Studies 1 and 2 and urban scenes in Studies 3 and 4. It is possible that the classroom environment provided a better psychological fit with the educational context and increased motivation through this alternate avenue (e.g., see Higgins, 2005, on fit effects). Future research should consider focusing on choosing a larger range of control images or testing outdoor urban scenes against indoor classroom scenes systematically.

A limitation to generalizing conclusions from these studies is the time of data collection. Data were collected in late 2021, 2022, and early 2023. Thus, participants were students who experienced the switch to online learning during the COVID-19 pandemic. Their experience of learning remotely in the unchanging environment of their home might have lessened sensitivity to visual cues in the materials. In other words, students who are used to learning in different and changing physical spaces (e.g., different classrooms) might be more sensitive to suggested environments in Zoom lecture background and mentally immerse themselves in the suggested environment.

Future Directions

An important future direction would be to examine the underlying reason for the positive association of nature relatedness and academic motivation and engagement. Perhaps this association is driven by greater well-being through interacting with nature more as a matter of course (Capaldi et al., 2015; Klootwijk et al., 2021). Perhaps this association is driven by third variables underlying both constructs, such as greater conscientiousness (Keaulana et al., 2021; Komarraju et al., 2009; Werner et al., 2019). It is important to note that any form of nature exposure increases nature connectedness (Nisbet et al., 2020; Nisbet & Zelenski, 2011; Soliman et al., 2017), so perhaps nature exposure happening outside the educational context (e.g., a weekend hike) can benefit academic motivation via increased nature relatedness. Educational psychology might look to the benefits of nature exposure in a broader context than within the educational space. For example, if creating outdoor classrooms is not possible, providing students with nature experience opportunities unrelated to their academics might still benefit their motivation and learning.

Even though the current study did not show evidence that minimal nature exposure improved the extent of academic engagement and motivation, motivation is a complex construct (e.g., Koenka, 2020) and other aspects of motivation such as the type of motivation (e.g., intrinsic or autonomous vs. extrinsic or controlled motivation, Deci & Ryan, 2008) or the orientation of motivation (e.g., toward the outcome versus the process, Touré-Tillery & Fishbach, 2014) might show more sensitivity to nature cues in instructional materials. Future research should also consider other types of academic outcomes that may be more fruitful. For example, previous research has shown the benefit of nature exposure on creativity (Palanica & Fossat, 2022), cognitive performance (Berman et al., 2008), productivity (Bringslimark et al., 2007; Larsen et al., 1998), and self-discipline (Kuo et al., 2019). These domains may be important avenues for future research.

Conclusions

Four studies underlined the relevance of nature relatedness in an educational context, with a positive association of feeling connected to nature and academic engagement and motivation. However, the studies also showed that integrating visual nature cues in instructional materials is unlikely to benefit student motivation in the way that nature immersion in outdoor classrooms or forest schools does. This research suggests that when considering nature exposure as a potential factor in increasing student well-being, structural changes to university campuses to integrate more natural spaces have greater promise than promoting nature exposure via small visual cues on print or online class materials.

Contributions

Contribution to conception and design: JED, JP, KP, CH, CO
Contributed to acquisition of data: JED, JP, KP, CH, CO
Contributed to analysis and interpretation of data: JED, JP
Drafted and/or revised the article: JED, JP
Approved the submitted version for publication: JED, JP, KP, CH, CO

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Competing Interests

There are no conflicts of interest to report.

Data Accessibility Statement

Study materials, data, data analysis code, and supplementary materials are available on the paper's project page on the Open Science Framework repository at https://osf.io/e7vy3/

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References

af Ursin, P., Järvinen, T., & Pihlaja, P. (2021). The role of academic buoyancy and social support in mediating associations between academic stress and school engagement in Finnish primary school children. *Scandinavian Journal of Educational Research*, *65*(4), 661–675. https://doi.org/10.1080/00313831.2020.1739135

Alivernini, F., & Lucidi, F. (2011). Relationship between social context, self-efficacy, motivation, academic achievement, and intention to drop out of high school: A longitudinal study. *The Journal of Educational Research*, *104*(4), 241–252. https://doi.org/10.1080/00220671003728062

Amrai, K., Motlagh, S. E., Zalani, H. A., & Parhon, H. (2011). The relationship between academic motivation and academic achievement students. *Procedia - Social and Behavioral Sciences*, *15*, 399–402. https://doi.org/10.1016/j.sbspro.2011.03.111

An, B. P., Loes, C. N., & Trolian, T. L. (2017). The relation between binge drinking and academic performance: Considering the mediating effects of academic involvement. *Journal of College Student Development*, *58*(4), 492–508. https://doi.org/10.1353/csd.2017.0039

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, *19*(12), 1207–1212. https://doi.org/10.1111/j.1467-9280.2008.02225.x

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., Kaplan, S., Sherdell, L., Gotlib, I. H., & Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*, *140*(3), 300–305. https://doi.org/10.1016/j.jad.2012.03.012

Beukeboom, C. J., Langeveld, D., & Tanja-Dijkstra, K. (2012). Stress-reducing effects of real and artificial nature in a hospital waiting room. *The Journal of Alternative and Complementary Medicine*, *18*(4), 329–333. https://doi.org/10.1089/acm.2011.0488

Braun, T., & Dierkes, P. (2017). Connecting students to nature – how intensity of nature experience and student age influence the success of outdoor education programs. *Environmental Education Research*, *23*(7), 937–949. https://doi.org/10.1080/13504622.2016.1214866

Bringslimark, T., Hartig, T., & Patil, G. G. (2007). Psychological benefits of indoor plants in workplaces: Putting experimental results into context. *HortScience*, *42*(3), 581–587. https://doi.org/10.21273/hortsci.42.3.581

Brown, D. K., Barton, J. L., & Gladwell, V. F. (2013). Viewing nature scenes positively affects recovery of autonomic function following acute-mental stress. *Environmental Science & Technology*, *47*(11), 5562–5569. https://doi.org/10.1021/es305019p

Capaldi, C., Passmore, H.-A., Nisbet, E., Zelenski, J., & Dopko, R. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing*, *5*(4), 1–16. https://doi.org/10.5502/ijw.v5i4.449

Carmona-Halty, M. A., Schaufeli, W. B., & Salanova, M. (2019). The Utrecht Work Engagement Scale for Students (UWES–9S): Factorial validity, reliability, and measurement invariance in a Chilean sample of undergraduate university students. *Frontiers in Psychology*, *10*, 1017. https://doi.org/10.3389/fpsyg.2019.01017

Chawla, L., Keena, K., Pevec, I., & Stanley, E. (2014). Green schoolyards as havens from stress and resources for resilience in childhood and adolescence. *Health & Place*, *28*, 1–13. https://doi.org/10.1016/j.healthplace.2014.03.001

Chiang, Y.-C., Li, D., & Jane, H.-A. (2017). Wild or tended nature? The effects of landscape location and vegetation density on physiological and psychological responses. *Landscape and Urban Planning*, *167*, 72–83. https://doi.org/10.1016/j.landurbplan.2017.06.001

Chou, W.-Y., & Hung, S.-H. (2021). Cumulative frequency of nature dose: How continuous and regular forest walking improves nature relatedness, restorativeness, and learning engagement in college students. *Sustainability*, *13*(20), 11370. https://doi.org/10.3390/su132011370

Dean, S. (2019). Seeing the Forest and the Trees: A Historical and Conceptual Look at Danish Forest Schools. *International Journal of Early Childhood Environmental Education*, *6*(3), 53–63.

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology*, *49*(3), 182–185. https://doi.org/10.1037/a0012801

Demir, Y., & Kutlu, M. (2018). Relationships among internet addiction, academic motivation, academic procrastination and school attachment in adolescents. *International Online Journal of Educational Sciences*, *10*(5). https://doi.org/10.15345/iojes.2018.05.020

Dettweiler, U., Ünlü, A., Lauterbach, G., Becker, C., & Gschrey, B. (2015). Investigating the motivational behavior of pupils during outdoor science teaching within self-determination theory. *Frontiers in Psychology*, *6*, 125. https://doi.org/10.3389/fpsyg.2015.00125

Dijkstra, K., Pieterse, M. E., & Pruyn, A. (2008). Stress-reducing effects of indoor plants in the built healthcare environment: The mediating role of perceived attractiveness. *Preventive Medicine*, *47*(3), 279–283. https://doi.org/10.1016/j.ypmed.2008.01.013

Dillon, J., Rickinson, M., & Teamey, K. (2016). The value of outdoor learning: evidence from research in the UK and elsewhere. In *Towards a Convergence Between Science and Environmental Education* (pp. 193–200). Routledge. https://doi.org/10.4324/9781315730486

Dopko, R. L., Capaldi, C. A., & Zelenski, J. M. (2019). The psychological and social benefits of a nature experience for children: A preliminary investigation. *Journal of Environmental Psychology*, *63*, 134–138. https://doi.org/10.1016/j.jenvp.2019.05.002

Fehnker, L., Pearson, D., & Howland, P. J. (2021). Exploring conceptualisations of 'connections to nature' from an environmental management perspective: A case study in Tāmaki Makaurau Auckland, Aotearoa New Zealand. *Australasian Journal of Environmental Management*, *29*(1), 46–63. https://doi.org/10.1080/14486563.2022.2035834

Fortier, M. S., Vallerand, R. J., & Guay, F. (1995). Academic motivation and school performance: Toward a structural model. *Contemporary Educational Psychology*, *20*(3), 257–274. https://doi.org/10.1006/ceps.1995.1017

Garden, A., & Downes, G. (2023). A systematic review of forest schools literature in England. *Education 3-13*, *51*(2), 320–336. https://doi.org/10.1080/03004279.2021.1971275

Goh, J. X., Hall, J. A., & Rosenthal, R. (2016). Mini meta-analysis of your own studies: Some arguments on why and a primer on how. *Social and Personality Psychology Compass*, *10*(10), 535–549. https://doi.org/10.1111/spc3.12267

Haluza-DeLay, R. (2001). Nothing here to care about: Participant constructions of "nature" following a 12-day wilderness program. *The Journal of Environmental Education*, *32*(4), 43–48. https://doi.org/10.1080/00958960109598662

Hartig, T., & Kahn, P. H., Jr. (2016). Living in cities, naturally. *Science*, *352*(6288), 938–940. https://doi.org/10.1126/science.aaf3759

Higgins, E. T. (2005). Value from regulatory fit. *Current Directions in Psychological Science*, *14*(4), 209–213. https://doi.org/10.1111/j.0963-7214.2005.00366.x

Howard, J. L., Bureau, J. S., Guay, F., Chong, J. X., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, *16*(6), 1300–1323. https://doi.org/10.1177/1745691620966789

Joye, Y., & Bolderdijk, J. W. (2015). An exploratory study into the effects of extraordinary nature on emotions, mood, and prosociality. *Frontiers in Psychology*, *5*, 1577. https://doi.org/10.3389/fpsyg.2014.01577

Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology*, *103*(1), 54–69. https://doi.org/10.1037/a0028347

Karadag, S. C. (2019). Psychosocial achievements of social studies teacher candidates in out door geography courses. *Review of International Geographical Education Online (RIGEO)*, *9*(3), 663–677.

Keaulana, S., Kahili-Heede, M., Riley, L., Park, M. L. N., Makua, K. L., Vegas, J. K., & Antonio, M. C. K. (2021). A scoping review of nature, land, and environmental connectedness and relatedness. *International Journal of Environmental Research and Public Health*, *18*(11), 5897. https://doi.org/10.3390/ijerph18115897

Khademi Ashkazeri, M., & Mofradnejad, N. (2019). Comparing the Theory of Mind, Motivation of Academic Achievement and Social Behavior in the Children of Nature and Ordinary Schools with Controlling Socioeconomic Status. *Environmental Education and Sustainable Development*, *7*(3), 23–34.

Klootwijk, C. L. T., Koele, I. J., van Hoorn, J., Güroğlu, B., & van Duijvenvoorde, A. C. K. (2021). Parental support and positive mood buffer adolescents' academic motivation during the COVID-19 pandemic. *Journal of Research on Adolescence*, *31*(3), 780–795. https://doi.org/10.1111/jora.12660

Koenka, A. C. (2020). Academic motivation theories revisited: An interactive dialog between motivation scholars on recent contributions, underexplored issues, and future directions. *Contemporary Educational Psychology*, *61*, 101831. https://doi.org/10.1016/j.cedpsych.2019.101831

Komarraju, M., Karau, S. J., & Schmeck, R. R. (2009). Role of the Big Five personality traits in predicting college students' academic motivation and achievement. *Learning and Individual Differences*, *19*(1), 47–52. https://doi.org/10.1016/j.lindif.2008.07.001

Kuo, M., Barnes, M., & Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-effect relationship. *Frontiers in Psychology*, *10*, 305. https://doi.org/10.3389/fpsyg.2019.00305

Largo-Wight, E., Guardino, C., Wludyka, P. S., Hall, K. W., Wight, J. T., & Merten, J. W. (2018). Nature contact at school: The impact of an outdoor classroom on children's well-being. *International Journal of Environmental Health Research*, *28*(6), 653–666. https://doi.org/10.1080/09603123.2018.1502415

Larsen, L., Adams, J., Deal, B., Kweon, B. S., & Tyler, E. (1998). Plants in the workplace: the effects of plant density on productivity, attitudes, and perceptions. *Environment and Behavior*, *30*(3), 261–281. https://doi.org/10.1177/001391659803000301

Li, H., Ding, Y., Zhao, B., Xu, Y., & Wei, W. (2023). Effects of immersion in a simulated natural environment on stress reduction and emotional arousal: A systematic review and meta-analysis. *Frontiers in Psychology*, *13*, 1058177. https://doi.org/10.3389/fpsyg.2022.1058177

Lipowski, M., Krokosz, D., Łada, A., Sližik, M., & Pasek, M. (2019). Sense of coherence and connectedness to nature as predictors of motivation for practicing karate. *International Journal of Environmental Research and Public Health*, *16*(14), 2483. https://doi.org/10.3390/ijerph16142483

Lockwood, P., Jordan, C. H., & Kunda, Z. (2002). Motivation by positive or negative role models: Regulatory focus determines who will best inspire us. *Journal of Personality and Social Psychology*, *83*(4), 854–864. https://doi.org/10.1037/0022-3514.83.4.854

Lohr, A. M., Krause, K. C., McClelland, D. J., Van Gorden, N., Gerald, L. B., Del Casino, V., Jr., Wilkinson-Lee, A., & Carvajal, S. C. (2021). The impact of school gardens on youth social and emotional learning: A scoping review. *Journal of Adventure Education and Outdoor Learning*, *21*(4), 371–384. https://doi.org/10.1080/14729679.2020.1838935

Malkoç, A., & Mutlu, A. K. (2018). Academic Self-Efficacy and Academic Procrastination: Exploring the Mediating Role of Academic Motivation in Turkish University Students. *Universal Journal of Educational Research*, *6*(10), 2087–2093. https://doi.org/10.13189/ujer.2018.061005

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, *24*(4), 503–515. https://doi.org/10.1016/j.jenvp.2004.10.001

Moran, D. (2019). Back to nature? Attention restoration theory and the restorative effects of nature contact in prison. *Health & Place*, *57*, 35–43. https://doi.org/10.1016/j.healthplace.2019.03.005

Nisbet, E. K., Shaw, D. W., & Lachance, D. G. (2020). Connectedness with nearby nature and well-being. *Frontiers in Sustainable Cities*, *2*, 1–18. https://doi.org/10.3389/frsc.2020.00018

Nisbet, E. K., & Zelenski, J. M. (2011). Underestimating nearby nature: Affective forecasting errors obscure the happy path to sustainability. *Psychological Science*, *22*(9), 1101–1106. https://doi.org/10.1177/0956797611418527

Nisbet, E. K., & Zelenski, J. M. (2013). The NR-6: A new brief measure of nature relatedness. *Frontiers in Psychology*, *4*, 813–824. https://doi.org/10.3389/fpsyg.2013.00813

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The Nature Relatedness Scale: Linking individuals' connection With nature to environmental concern and behavior. *Environment and Behavior*, *41*(5), 715–740. https://doi.org/10.1177/0013916508318748

Ojala, A., Neuvonen, M., Kurkilahti, M., Leinikka, M., Huotilainen, M., & Tyrväinen, L. (2022). Short virtual nature breaks in the office environment can restore stress: An experimental study. *Journal of Environmental Psychology*, *84*, 101909. https://doi.org/10.1016/j.jenvp.2022.101909

Osborne, J. W., & Jones, B. D. (2011). Identification with academics and motivation to achieve in school: How the structure of the self influences academic outcomes. *Educational Psychology Review*, *23*(1), 131–158. https://doi.org/10.1007/s10648-011-9151-1

Ouweneel, E., Le Blanc, P. M., & Schaufeli, W. B. (2011). Flourishing students: A longitudinal study on positive emotions, personal resources, and study engagement. *Journal of Positive Psychology*, *6*(2), 142–153. https://doi.org/10.1080/17439760.2011.558847

Palanica, A., & Fossat, Y. (2022). Effects of nature virtual backgrounds on creativity during videoconferencing. *Thinking Skills and Creativity*, *43*(2), 100976. https://doi.org/10.1016/j.tsc.2021.100976

Pensini, P., Horn, E., & Caltabiano, N. J. (2016). An exploration of the relationships between adults' childhood and current nature exposure and their mental well-being. *Children, Youth and Environments*, *26*(1), 125–147. https://doi.org/10.1353/cye.2016.0027

Pointon, P. (2013). 'The city snuffs out nature': young people's conceptions of and relationship with nature. *Environmental Education Research*, *20*(6), 776–794. https://doi.org/10.1080/13504622.2013.833595

Rump, M., Esdar, W., & Wild, E. (2017). Individual differences in the effects of academic motivation on higher education students' intention to drop out. *European Journal of Higher Education*, *7*(4), 341–355. https://doi.org/10.1080/21568235.2017.1357481

Soga, M., Evans, M. J., Tsuchiya, K., & Fukano, Y. (2021). A room with a green view: the importance of nearby nature for mental health during the COVID-19 pandemic. *Ecological Applications*, *31*(2), e2248. https://doi.org/10.1002/eap.2248

Sohail, N. (2013). Stress and academic performance among medical students. *Journal of the College of Physicians and Surgeons Pakistan*, *23*(1), 67–71.

Soliman, M., Peetz, J., & Davydenko, M. (2017). The impact of immersive technology on nature relatedness and pro-environmental behavior. *Journal of Media Psychology*, *29*(1), 8–17. https://doi.org/10.1027/1864-1105/a000213

Stevenson, M. P., Dewhurst, R., Schilhab, T., & Bentsen, P. (2019). Cognitive restoration in children following exposure to nature: evidence from the attention network task and mobile eye tracking. *Frontiers in Psychology*, *10*, 42. https://doi.org/10.3389/fpsyg.2019.00042

Strong, L. (2019). *Classrooms Without Walls: A study in Outdoor Learning Environments to Enhance Academic Motivation for K-5 Students* [Thesis]. California State Polytechnic University, Pomona.

Touré-Tillery, M., & Fishbach, A. (2014). How to measure motivation: A guide for the experimental social psychologist. *Social and Personality Psychology Compass*, *8*(7), 328–341. https://doi.org/10.1111/spc3.12110

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*(3), 201–230. https://doi.org/10.1016/s0272-4944(05)80184-7

Van den Berg, A. E., Jorgensen, A., & Wilson, E. R. (2014). Evaluating restoration in urban green spaces: Does setting type make a difference? *Landscape and Urban Planning*, *127*, 173–181. https://doi.org/10.1016/j.landurbplan.2014.04.012

Vining, J., Merrick, M. S., & Price, E. A. (2008). The distinction between humans and nature: Human perceptions of connectedness to nature and elements of natural and unnatural. *Human Ecology Review*, *15*(1), 1–11.

Wells, G. L., & Windschitl, P. D. (1999). Stimulus sampling and social psychological experimentation. *Personality and Social Psychology Bulletin*, *25*(9), 1115–1125. https://doi.org/10.1177/01461672992512005

Werner, K. M., Milyavskaya, M., Klimo, R., & Levine, S. L. (2019). Examining the unique and combined effects of grit, trait self-control, and conscientiousness in predicting motivation for academic goals: A commonality analysis. *Journal of Research in Personality*, *81*, 168–175. https://doi.org/10.1016/j.jrp.2019.06.003

Yang, Y., Wang, L., Passmore, H.-A., Zhang, J., Zhu, L., & Cai, H. (2020). Viewing nature scenes reduces the pain of social ostracism. *The Journal of Social Psychology*, *161*(2), 197–215. https://doi.org/10.1080/00224545.2020.1784826

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