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Research Paper

Integrating off-site visitor education into landscape conservation and management: An examination of timing of educational messaging and compliance with low-impact hiking recommendations

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HIGHLIGHTS

- The treatment improved participants' intent to stay on the trail.
- The treatment improved participants' knowledge levels.
- The treatment promoted positive attitudes toward staying on the trail.
- A short time difference did not change the effects of the educational message.
- Results supported the use of off-site visitor education programs.

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ABSTRACT

The protection of landscapes from environmentally-damaging recreational impacts requires planning and design for proactive visitor education. We examined how the timing of off-site educational messaging influences individuals' compliance with, knowledge of, and attitudes towards two low-impact recreation behavioral recommendations (i.e., hiking on muddy or wet trail sections and walking on trail steps rather than around them) using a laboratory-based experiment. The educational message used in the experiment consisted of a video and short summary statements about low-impact hiking recommendations. Participants were randomly assigned to one of three experimental groups: 1) viewing the message at least 24 h before the experiment; 2) viewing the message immediately before the experiment; or 3) not viewing the message at all (control). We assessed participants' hiking intentions by asking them to draw their intended hiking routes on a large LCD display depicting short sections of the Appalachian Trail in North Carolina and Tennessee. Participants' intended routes were coded as either complying or not complying with the low-impact hiking recommendations. For participants who received the educational message, knowledge about and attitudes toward low-impact hiking were measured twice, immediately after viewing the message and at the end of the experiment. Our analyses revealed the educational message significantly improved participants' knowledge levels, attitudes, and intentions to comply with low-impact hiking recommendations. The timing of when the educational message was viewed/read by participants, however, did not influence their knowledge levels, attitudes, or intentions to comply. These findings suggest low-impact recreation behavior can be influenced through educational messages delivered before outdoor recreationists begin their trips.

1. Introduction

Nature-based recreation activities are part of the anthropogenic forces that constantly alter natural landscapes. The environmental impacts of recreation on soil, vegetation, water, wildlife, and other elements of ecosystems may seem trivial at the individual level, but when these impacts are multiplied by the volume of visitation to

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recreation settings and repeated over time, they can interact with each other in complicated ways that alter ecosystem functioning (Marion, Leung, Eagleston, & Burroughs, 2016). For example, if hikers choose to avoid steps on steep trails, their trampling of soils along the trail will likely cause soil compaction and erosion (Moore & Driver, 2005). This soil compaction and erosion, in turn, may cause increased run-off and sedimentation in streams at lower elevations. Over time, the landscape will be marked with deep-cut wide barren trails, damaged vegetation, and decreased water quality. The consequences are degraded aesthetic, natural, and recreational values of the landscape.

To protect landscapes from negative recreational impacts while providing recreation-related and ecosystem services benefits to the public, land and water managers often try to educate recreationists about behaviors to avoid or reduce the negative environmental impacts of recreation with on-site activities and resources such as education programs and signs, posters, interpretation, personal contact and other communication tools (Marion & Reid, 2007). However, with steadily growing visitation levels at many outdoor recreation destinations, it is becoming increasingly difficult for on-site visitor information and education programs to reach rapidly growing numbers of visitors (Jacobi, 2003). As a result, proactive off-site visitor education may serve as an efficient and effective approach to educating recreationists about the negative environmental impacts of recreation, subsequently improving the ability to sustainably manage landscapes used for recreation. Outdoor recreationists who are poorly informed about responsible recreation behavior before they arrive at their destination are more likely to be either ill-prepared to recreate in an environmentally-responsible manner (e.g., not bringing the gear necessary to dispose of waste properly) or simply be unaware of what responsible recreation behaviors are. Either of these situations are likely to lead to high-impact recreation behaviors (Hayes, 2008; Reigner & Lawson, 2009). It is unlikely that on-site signage alone will dissuade recreationists from visiting sought-after parts of destinations they have traveled long distances to experience (Hayes, 2008). Some previous studies suggest visitor information and education programs are more effective when delivered early in the overall recreation experience such as during trip planning (Manning, 2011; Marion, 2014). Off-site visitor education programs may be able to proactively target and communicate with prospective outdoor recreationists, leading to more sustainable landscape management.

Reaching visitors before they arrive at a destination is not a new concept for outdoor recreation planners, resource managers, or environmental educators (Bromley, Marion, & Hall, 2013; Daniels & Marion, 2005; Doucette & Cole, 1993; Manfredo & Bright, 1991). Web-based technologies, such as social media and emails, provide fast and potentially cost-effective avenues for communicating with large and diverse audiences (National Parks Conservation Association, 2009). Electronic communication can deliver educational messages with images and videos that directly demonstrate responsible recreation behaviors. Natural resource managers, such as the National Park Service, have shown growing interest in reaching out to constituents through online communication channels such as emails and social media (National Parks Conservation Association, 2009). Through online pre-trip registration and permitting efforts, such as the Appalachian Trail Conservancy's voluntary long-distance hiker registration system, natural area managers do have the ability to directly target and communicate with prospective visitors. Off-site education programs can also help reduce the need for on-site infrastructure and materials, such as signs or brochures, as well as personnel, such as rangers and interpreters, tasked with educating the public about responsible recreation behavior (labor costs are often among the most substantial and significant in terms of providing outdoor recreation opportunities; Siderelis, Moore, Leung, & Smith, 2012).

Despite the potential for using web-based technologies to educate visitors about low-impact recreation behavior prior to their trips, questions remain about how to successfully plan and design an off-site visitor education program. One important question is how the delay between when individuals receive an educational message and when they arrive on-site and face situations where they must choose to comply with low-impact recreation recommendations influences the educational message's effectiveness. This study set out to examine the relationship between visitor education messaging timing and behavioral change using a theoretically-grounded laboratory-based experimental study.

2. Theoretical background

There are two well-documented lines of research regarding the potential effects of educational messaging timing on individual compliance with low-impact recreation behavioral recommendations: 1) the forgetting-curve hypothesis based on Ebbinghaus' classic memory theory; and 2) the stable-attitude hypothesis based on the Theory of Planned Behavior and the Elaboration Likelihood Model (cited in Eagly & Chaiken, 1993a).

The forgetting-curve hypothesis suggests the longer the time between when a message regarding low-impact recreation behavioral recommendations is delivered and when the targeted recreation behavior occurs, the less likely individuals will be to change their behaviors. This hypothesis is based on Ebbinghaus' negatively accelerating forgetting curve concept, which posits that as time passes, individuals forget much of what they learned when reading or viewing an educational message (cited in Eagly & Chaiken, 1993a). A variety of classic (e.g., Miller & Campbell, 1959; Watts & McGuire, 1964) as well as recent (e.g., Erdelyi, 2010; Murre & Dros, 2015) studies have supported Ebbinghaus' forgetting curve concept.

In contrast, the stable-attitude hypothesis suggests that if an educational message is able to change individuals' attitudes, those attitudes will remain stable and continue to influence behaviors over time. This hypothesis is supported by the Theory of Planned Behavior in which attitudes toward a behavior are a major determinant of volitional behavior (Eagly & Chaiken, 1993c). The hypothesis is also supported by the Elaboration Likelihood Model which proposes attitudinal changes result in temporally-persistent influences on behavior (Eagly & Chaiken, 1993b). Compared to the forgetting-curve hypothesis, the stable-attitudes hypothesis posits the stability of attitudes could overcome the effects of individuals' tendency to forget the content of educational messages as it becomes more temporally remote.

Each of these opposing hypotheses has received some empirical support. However, no previous research has tested the two hypotheses in the same study. Two recreation studies have supported the forgetting curve hypothesis. Manfredo and Bright (1991) found that 76% of visitors to a Wilderness area in Minnesota recalled receiving an information packet sent by a land management agency prior to taking their trip. However, only 11% indicated their behavior changed as a result of receiving the information. It suggests visitors might be able to recall the off-site educational message, but also indicates recall alone is not necessarily enough to change recreationists' behaviors. Bradford and McIntyre (2005) tested how the locations of educational messages as well as the message content influenced visitors' off-trail hiking behavior. They found messages located at undesignated trail sites (where the undesirable off-trail hiking behavior is likely to occur) were most likely to reduce off-trail use, compared to the same messages presented at information booths. A possible explanation for this finding is the temporal delay between when participants received the educational message at the information booth and when the off-trail hiking behavior might occur.

On the other hand, although the effects of attitudes on low-impact behavior and behavioral change have been widely examined and supported (Brown, Ham, & Hughes, 2010; Hughes, Ham, & Brown, 2009; Lawhon, 2013; Reigner & Lawson, 2009; Vagias, Powell, Moore & Wright, 2014), much less research has been conducted on how attitudes change over time, particularly after an educational message. The support for the Elaboration Likelihood Model of persuasion in the context of low-impact recreation behavior is mixed as well. Manfredo and Bright (1991) used cross-sectional data and found the number of thoughts generated by visitors about the information package moderately predicted the acquisition of new beliefs and changes to prior beliefs, which then significantly predicted self-reported behavior change. Conversely, Jones (2004) found the time individuals spent thinking about a specific behavior, as well as the number of reasons they could list to adopt the behavior (two measures commonly used to operationalize the Elaboration Likelihood Model) were not significant predictors of a variety of low-impact recreation behaviors.

In sum, we did not find sufficient empirical evidence in the literature to conclude which hypothesis better explains how the timing of educational messages influences low-impact recreation behavior. It is unclear whether the temporal delay between message delivery and behavior follows the forgetting curve and leads to less behavioral changes over time or, conversely, whether educational messages alter individual attitudes in a significant and persistent enough manner to alter future recreation behavior. Answering these questions is critical for planning and designing proactive visitor education. Given this, we set out to examine whether or not when an educational message is received influences individuals' compliance with, knowledge about, and attitudes toward low-impact hiking recommendations. Collectively, our research questions were:

RQ1Does the timing of a low-impact hiking educational message influence individuals' compliance with low-impact hiking recommendations?RQ2Does the timing of a low-impact hiking educational message influence individuals' knowledge levels and retention of the information received through that message?RQ3Does the timing of a low-impact hiking educational message influence individuals' attitudes towards low-impact hiking behaviors?

3. Methods

3.1. Study design

This study used an intervention-based experimental design with two treatment groups and a control group to test the effects of the timing of an educational message on: 1) individuals' compliance with low-impact hiking recommendations; 2) their knowledge level and retention of information received through the educational message; and 3) their attitudes towards low-impact hiking behavior. Data were collected via a pre-survey, a lab-based simulation, and a post-survey. The pre-survey, administered immediately *after* participants viewed the educational message, solicited information on individuals' knowledge of low-impact hiking recommendations and their attitudes towards two low-impact hiking behaviors. The laboratory-based simulation involved presenting photos of actual trail segments with degraded conditions to participants in a controlled setting and asking them to indicate how they would navigate that segment if confronted with those conditions on an actual hike. The post-survey, administered immediately after the experiment, was used to reassess individuals' knowledge of low-impact hiking recommendations and their attitudes towards two low-impact hiking behavior. The post-survey was also used to collect data on participants' socio-demographic characteristics and levels of backcountry and hiking experience.

Participants were undergraduate students at a major U.S. research university. University students are a major source of current and future visitors to natural areas, including the Appalachian Trail, this study's area of interest. For example, two studies of Appalachian Trail users found that over 90% of Appalachian Trail long-distance hikers have some level of college education (Adams, 2014; Manning et al., 2000). Understanding university students' low-impact recreation behaviors and the determinants of those behaviors is important to the sustainability of such natural areas. It is also of managerial interest to better understand young adults as an important and growing user group. A total of 67 participants were recruited from courses related to sport, recreation or tourism management in April 2016.

A Random Block Control Design was used to assign participants to three groups: two experimental groups, and a control. The two experimental groups were designed to either receive an email with the educational message three days before the experiment (Group 1) or receive the educational message in the lab immediately before the experiment (Group 2). The Control group did not receive the educational message.

3.2. Materials and measures

3.2.1. Educational message

We used an educational message to inform participants about low-impact hiking behaviors under two types of degraded trail conditions: 1) a muddy and wet trail; and 2) a steep trail with management-installed steps and user-created routes around the steps. The educational message was designed to inform participants that when encountering muddy trails or user-created side trails, the desired hiking behavior is to walk through the mud or use the management-installed steps to avoid widening the trail.

The educational message consisted of a video followed by short written statements about desirable hiking behaviors when encountering degraded trail conditions. The selected video was part of a *Don't be that Guy* series developed by the Appalachian Trail Conservancy in 2015 to promote Leave No Trace principles on the Appalachian Trail (https://www.youtube.com/watch?v=SLhFAuKsGuk&list=PLuekIhaoBuWZ0c4R2jd3RE4PgjDwg9NOp&index=5). The Leave No Trace principles were developed by the Leave No Trace Center for Outdoor Ethics and natural resource management agencies to promote low-impact recreation behaviors and reduce recreation impacts. The video focused on the Leave No Trace principle of "travel and camp on durable surfaces" and lasted 89 s. The story line involves an individual (i.e., "that guy") who unintentionally generates environmental impacts along the Appalachian Trail by not following Leave No Trace guidelines.

Three short statements based on the related Leave No Trace principles about walking through mud on trails and walking on steps rather than around them were listed immediately after the video (Fig. 1). Two of the statements were rephrased slightly from those provided in the video. The third statement was about walking on wood or stone steps rather than around them, which was not directly presented in the video. Information from the Appalachian Trail Conservancy's Leave No Trace campaign and the educational materials from the Leave No Trace Center for Outdoor Ethics were used to develop the statements which were reviewed by experts in Leave No Trace and trail maintenance before being included in the study. The statements were pilot tested with five reviewers to ensure they were clear and unambiguous.

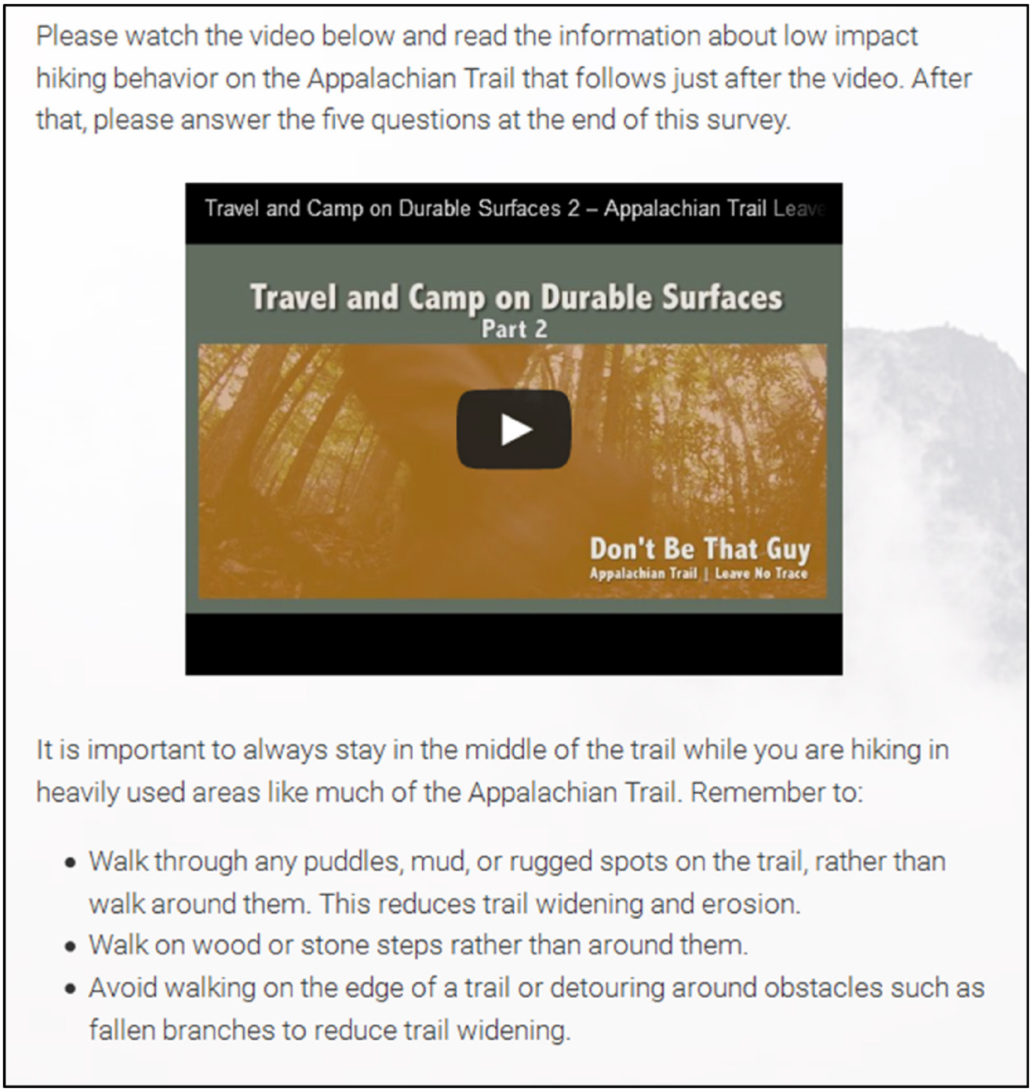

Fig. 1. Screen-shot of the educational message including the video and summary statements.

3.2.2. Knowledge and attitudes

In Groups 1 and 2, participants' knowledge and attitudes about the low-impact hiking behaviors were measured through both pre- and post-surveys administered on either end of the laboratory-based portion of the study. The pre-survey was administered immediately after the educational message was viewed/read. For participants who were assigned in Group 1, the pre-survey was administered through an online questionnaire delivered via email. Participants who were assigned to Group 2 completed the pre-survey on a laptop in the lab immediately before viewing trail images. Participants in the Control group did not take the pre-survey. All participants completed the post-survey; the survey was administered immediately after participants viewed trail images.

During the pre-survey, participants were asked to select hiking behaviors that were recommended in the video and statements they were just exposed to (i.e., knowledge) using a "check all that apply" question with three options: 1) "if there is a mud puddle in the middle of the trail, get muddy and walk right through it"; 2) "if you encounter wood or stone steps, walk on them rather than around them"; and 3) "if the trail is not totally dry, choose the wet part to step on rather than walking on dry barren soil or grasses along the edges". These options were phrased slightly differently from the statements in the educational message to test participants' comprehension. All the behaviors described in the statements followed low-impact hiking recommendations. If participants comprehended the educational message, they should have selected all three options. The first two statements were directly recommended in the educational message and corresponded to the trail conditions presented in the photos participants would see during the laboratory-based portion of the study. The third statement intentionally involved an inference from information in the video and statements. Data were recorded as three binary variables, one for each statement (1 = the participant selected the behavior as recommended; 0 = the participant did not select the behavior as recommended).

After the knowledge questions, we measured attitudes toward two low-impact hiking behaviors: 1) "Walking through any puddles, mud or rugged spots on the trail, rather than walking around them"; and 2) "Walking on wood or rock steps rather than around them". Attitudes were measured through six semantic differential scales intended to elicit a wide range of attitudinal responses. The seven-point bi-polar scales included the following anchors: good-bad; wise-foolish; pleasant-unpleasant; easy-hard; convenient-tiresome; and necessary-not necessary. These anchor words were adapted from Ajzen (2001).

During the post-survey, participants responded to the same knowledge and attitudes scales. Instead of asking participants in the Control group to recall information provided in the educa-

Fig. 2. Trail photos used in this study. From top left to bottom right are trail conditions 1 through 7. Trail conditions 1 through 4 depicted muddy and wet trails. Trail conditions 5 through 7 depicted trails with steps.

tional messages, they were asked to select the hiking behaviors recommended by the Appalachian Trail Conservancy. The post-survey also included questions about participants' demographic characteristics, their frequency of hiking, their level of backcountry experience and their experience with hiking on the Appalachian Trail.

Fig. 3. Examples of aggregated routes drawn by respondents.

3.2.3. Laboratory-based simulations

Seven trail photos were used to simulate hiking settings so that participants could choose which part of the trail they would use if actually hiking through that section. All photos were taken by one of the researchers on sections of the Appalachian Trail in Great Smoky Mountains National Park in North Carolina and Tennessee. To correspond with the educational message, the photos depicted two types of degraded trail conditions: muddy trails, and steep trails with either wood or rock steps and user-created routes around the steps. Four of the seven photos used in the laboratory-based portion of the study depicted muddy trails and three depicted steps (Fig. 2). The photos provided a clear focus on the trail corridor without visual distractions such as human figures or overly shaded areas.

Once participants completed the informed consent form (and the pre-survey only for participants in Group 2) in the lab, they were guided to a position about 4-feet from a 60-inch LCD display with touch screen functionality. Participants were first asked to practice drawing routes on two non-study trail images while imagining they were actually hiking on the trail depicted in the image. Participants were encouraged to step back and forth to get a full view of the trail conditions. After participants indicated they understood the task, the following narrative description of a hypothetical hiking experience was read to them and presented on-screen:

> It is a sunny Saturday afternoon in mid-March. You are hiking on the Appalachian Trail in Great Smoky Mountains National Park carrying a light backpack and wearing hiking boots. It snowed earlier this week, but the temperature has risen to about 60°.

The description was intended to give necessary contextual information about the simulated hiking trip. The time and temperature descriptions matched the conditions under which the photos were taken. The description about carrying a light backpack and wearing hiking boots was added to control for possible variability in hiking intentions not caused by the treatment, but by how participants might imagine their hiking experience.

Participants' hiking intentions were measured by asking them to indicate the route they would take on each of the seven trail images by using their finger to trace their route directly on the screen. Participants were encouraged to draw the routes they would actually take if they were hiking on the trail section in question (For examples of participants' drawing please see Fig. 3). There were no restrictions about where they could draw their intended routes. This task took about three to four minutes to complete for all of the images. Before the session concluded, participants were instructed to sit back down and complete the online post-survey using a laptop set up by the researcher.

3.3. Data analysis

3.3.1. Coding

To improve impartiality and avoid coding errors, a single-blind approach was used to code participants' hiking intentions (Schulz & Grimes 2002). One of the authors with extensive trail knowledge, and who was unaware of participants' treatment assignments, coded the routes drawn on the photos to one of four categories: 1) fully compliant; 2) mostly compliant; 3) mostly non-compliant; or 4) fully non-compliant. All photos were randomly ordered to avoid the coder potentially remembering participants' earlier performance and thus introducing bias. The coding process was also facilitated with a low-impact hiking corridor pre-marked on each of the original seven trail photos that was consistent with the recommendations made in the video message. The corridors delineated with boundaries at the left, right and top of the photo and were developed by the author with extensive experience in trail management, visitor behavior, and outdoor recreation research. When the line a participant drew fell completely inside or outside of the low-impact hiking corridor, the intended hiking behavior was coded as either full compliance or full non-compliance, respectively. When the drawn lines crossed over the boundaries of the low-impact-hiking corridor, the behavior was coded as either mostly compliant or mostly non-compliant based on the proportion of the drawn line that fell inside or outside the low-impact hiking corridor and the level of likely impact expected where the line was drawn. The lines delineating the corridor were only used for coding and were not visible to participants.

For data analysis, behavioral responses were collapsed into two categories with the first consisting of fully compliant and mostly compliant intentions and the second consisting of mostly non-compliant and fully non-compliant intentions. Changing the hiking intention into a binary variable enabled more interpretable analyses and helped mitigate possible concerns over low counts in any one of the behavioral response options.

3.3.2. Analysis

A total of 47 participants finished the entire study and passed the treatment check (for details for treatment check see Supplementary Material A), including 18 participants in Group 1, 16 participants in Group 2, and 13 participants in the Control group. Within Group 1, seven (38.9%) viewed/read the educational message three days before the lab-based portion of the study, three (16.7%) viewed/read the educational message two days before the lab-based portion of the study and seven (38.9%) viewed/read the educational message one day prior to the lab-based portion of the study. This was different from our original experimental design (i.e., all viewing the educational message three days before) and reflects the common difficulty of requiring all participants to fully follow instructions. As a pre-analysis, we conducted a logistic regression with behavior intention as the dependent variable, and how many days before the experiment the participants received the educational message as a predictor. We found the effect of the number of days on Group 1 participants' compliance with low-impact recreation recommendations was not significant and, therefore, merged all these participants as Group 1. The data set was restructured with each data line representing one stated choice made by one participant under one trail conditions. Each participant contributed seven data lines to the data. The final data set for analysis included 329 stated choices about participants' hiking intentions.

Analyses were conducted using SAS version 9.4. For RQ1, we analyzed the influence of educational message timing on participants' behavioral intentions with two mixed-effects logistic models using the PROC GLIMMIX procedure. The response was a binary variable for all models with "1" indicating "compliance with low-impact hiking recommendations" and "0" indicating "non-compliance with low-impact hiking recommendations". The first model included treatment as a fixed-effect and photo and participant as random effects. The second model added variables that might confound the treatment effects, including participants' hiking frequency, level of backcountry experience, Appalachian Trail hiking experience and age. The same model was fit to participants in Group 1 and 2 to test the effects of timing.

For RQ2, we analyzed the influence of the educational message and its timing on participants' knowledge level and retention of information using mixed-effects logistic regression models with knowledge level as the response, treatment group as a fixed-effect, and participants and participants' knowledge statements as random effects using the PROC GLIMMIX procedure. The responses in all models were binary, with "1" indicating the participant knew the stated hiking behavior was recommended and "0" indicating they did not know the statement depicted a recommended low-impact hiking behavior. The first model compared the post-survey knowledge indicators among all three groups to examine the overall effect of the educational message on knowledge level. The second model was also fit to post-survey data but focused only on participants from Group 1 and 2 to address the timing effect on knowledge levels. Using data from both pre- and post-surveys, the third mixed-effects logistic regression model examined the retention of information from pre-survey to post-survey for participants in Group 1 and Group 2.

For RQ3, we analyzed the influence of educational message timing on attitudes towards low-impact hiking behaviors using MANOVAs and one-way ANOVAs for each behavior using the PROC GLM procedure. For the MANOVA models, the six attitude measures collected in the post-survey were the multivariate response and treatment group was the factor. Additionally, one-way ANOVAs with post-hoc analyses were conducted for each attitude measure collected in the post-survey (e.g., good-bad; wise-foolish; pleasant-unpleasant; easy-hard; convenient-tiresome; and necessary-not necessary). The stability of attitudes was tested using MANOVAs with repeated measures. Additionally, 24 paired *t*-tests were conducted to compare the pre- and post-survey attitudes scores (two types of trail conditions $\times$ six attitude measures $\times$ two treatment groups). Bonferroni multi-comparison adjustment was used.

4. Results

4.1. Participants' profiles

Of the 47 participants included in the analysis, the majority were female (61.7%), white (93.6%) and had an average age of 21.6 (for details of participants' profiles see Supplementary Material B). About half (51.1%) of participants indicated they hiked, walked or ran on unpaved trails between one and five times a year, followed by 31.9% of participants who indicated hiking, walking or running on unpaved trails more than 10 times a year. On average, participants rated their level of backcountry experience towards the novice end of the scale ($\bar{x}$ = 3.2, *S.D.* = 1.7, on a seven-point scale, 1 = *novice*, 7 = *expert*). About 57.4% of participants had not hiked on the Appalachian Trail. Of the 17 participants who had hiked on the Appalachian Trail, the majority (82.4%) had hiked on sections in North Carolina.

Table 1
Compliance rates with low-impact hiking recommendations by groups and trail conditions.

	Overall	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7
All	64.7	75.6	75.6	56.5	40.4	89.1	53.2	76.1
Group1	68.8	82.4	55.6	66.7	33.3	88.9	66.7	88.9
Group2	78.0	81.3	80.0	75.0	68.8	93.3	68.8	80.0
Control	42.7	58.3	53.8	16.7	15.4	84.6	15.4	53.8

Note: TC: trail condition. Trail conditions #1 through #4 were muddy and wet trails. Trail conditions #5 through #7 were trails with steps.

4.2. RQ1: does the timing of a low-impact hiking educational message influence individuals' compliance with low-impact hiking recommendations?

The results suggested that overall the educational message was effective in improving participants' compliance with low-impact hiking recommendations. As shown in Table 1, across all three groups, the specific compliance rates for trail conditions ranged from 40.4% (Trail condition 4) to 89.1% (Trail condition 5). Group 2 had the highest average compliance rate (78.0%), followed by Group 1 (68.8%) and then the Control group (42.7%). The differences among the three groups were significant (F (2, 270) = 5.82, p-value = 0.0033). The predicted probability of low-impact hiking behavior across trail conditions was 0.74 for Group 1, 0.86 for Group 2, and 0.42 for the Control group. After adding participants' hiking frequency, level of backcountry experience, Appalachian Trail hiking experience and age as control variables, the treatment effect was still significant (F(2,269) = 6.35, p-value = 0.0020). Hiking frequency was the only significant control variable to predict compliance with low-impact hiking recommendations (F(3,269) = 4.68, p-value = 0.0033). Individuals reporting they hiked more than 10 times per year were most likely to follow low-impact hiking behavioral recommendations, while individuals who hiked 6–10 times a year were least likely to comply with low-impact hiking recommendations. The apparent non-linear relationship between hiking experiences and low-impact hiking behavior is interesting. One may speculate individuals with some hiking experiences, but short of expertise, may be confident with their hiking knowledge but not necessarily care to or know how to protect the trail.

To assess timing effects, we used another logistic regression with random effects and control variables for only the two experimental groups (i.e., Group 1 and Group 2). Those results revealed no significant differences in the intention to comply between the two groups (F (1, 193) = 0.44, p-value = 0.5091). The timing of our low-impact educational message did not influence individuals' compliance with low-impact hiking recommendations, after controlling for the effects of hiking frequency, level of backcountry experience and age.

Table 2
Participants' selection accuracy rates by group and knowledge items.

	Post-survey				Pre-survey
	Overall	Item 1	Item 2	Item 3	Overall
Overall	75.2	74.5	95.7	55.3	–
Group1	83.3	83.3	94.4	72.2	81.5
Group2	85.4	100.0	93.8	62.5	77.1
Control	51.3	30.8	100.0	23.1	–

Note: The selection accuracy rate was calculated as the total proportion of knowledge items correctly identified as low-impact hiking behaviors from the total number of knowledge items presented. Item 1: if there is a mud puddle in the middle of the trail, get muddy and walk right through it. Item 2: if you encounter wood or stone steps, walk on them rather than around them. Item 3: if the trail is not totally dry, choose the wet part to step on rather than walking on dry barren soil or grasses along the edges.

4.3. RQ2: does the timing of a low-impact hiking educational message influence individuals' knowledge levels and retention of the information delivered through that message?

Data from the post-survey indicated most participants were able to correctly recognize at least two of the three correct recommended low-impact hiking behaviors. About half (46.8%) of participants were able to recognize all three recommended low-impact hiking behaviors, followed by 31.8% participants who were able to recognize two recommended low-impact hiking behaviors. Over 95% of participants were able to recognize item 2, "if you encounter wood or stone steps, walk on them rather than around them", as recommended (Table 2). This was followed by item 1 "if there is a mud puddle in the middle of the trail, get muddy and walk right through it" with 74.5% of participants identifying it correctly as a low-impact hiking behavior. Participants had more difficulty recognizing the third hiking behavior, "if the trail is not totally dry, choose the wet part to step on rather than walking on dry barren soil or grasses along the edges" (selection accuracy rate = 55.3%), as a recommended low-impact hiking behavior. Part of the differences among knowledge items could have been due to the fact the third behavior was not directly addressed in the educational messages, whereas the first two hiking behaviors were.

The difference in the knowledge level measured in the post-survey among the three groups was significant (F (2, 92) = 7.58, p-value = 0.0009), with Group 2 having the highest probability of being able to correctly identify low-impact hiking behaviors (0.90), followed by Group 1 (0.89). The Control group had the lowest probability of being able to correctly identify low-impact hiking behaviors (0.53), suggesting that the educational message increased participants' knowledge levels. Another model only for participants in the two experimental groups revealed no significant difference between Group 1 and Group 2 (F (1, 66) = 0.08, p-value = 0.7728), suggesting the timing of the educational message did not influence knowledge retained. Using a logistic regression model with repeated measures, we found no significant effects of message timing (F (1, 4) = 0.08, p-value = 0.7906) or interaction between treatment and the timing on the knowledge measures (F (1, 98) = 0.42, p-value = 0.5183), suggesting knowledge was retained during the time interval between receiving the message and the experiment.

4.4. RQ3: does the timing of a low-impact hiking educational message influence individuals' attitudes towards two low-impact hiking behaviors?

Two specific attitudes were examined including attitude toward walking through puddles, mud, or rugged spots on the trail, and attitude toward walking on wood or rock steps rather than around them.

4.4.1. Attitudes toward walking through puddles, mud, or rugged spots on trails

After the experiment, most participants considered walking through puddles, mud or rugged spots on the trails as good ($\bar{x}$= 1.7), wise ($\bar{x}$= 1.2), relatively easy ($\bar{x}$= 0.9) and necessary ($\bar{x}$= 1.3), but showed mixed responses about whether the behavior was convenient ($\bar{x}$= 0.2) or pleasant ($\bar{x}$= −0.2, Supplementary Material C).

A significant difference was observed across the attitude measures in the post-survey among three groups (Wilks' Lambda = 0.50, F (12, 78) = 2.69, p-value = 0.0044), suggesting an effect of the educational message on overall attitudes toward walking through puddles, mud or rugged spots. Follow-up univariate analyses (one-way ANOVA) for each attitude measure revealed that participants who received an educational message considered walking through puddles, mud or rugged spots significantly better, wiser, more pleasant, and necessary relative to those participants who had not received the educational message (Table 3). No significant differences were found for the other two attitude measures using the easy-hard and convenient-tiresome anchor-pairs. Post-hoc comparisons found most differences were between the Control group and each of the two treatment groups. No significant differences were found between Groups 1 and 2, suggesting the timing of educational messaging did not influence participants' attitudes toward walking through puddles, mud or rugged spots on trails.

MANOVA with repeated measures revealed no difference between pre- and post-survey attitudes scores (Wilks' Lambda = 0.79, F (6, 27) = 1.20, p-value = 0.3341). We did not find any significant differences using t-tests either (Table 3), suggesting the timing of educational messages did not influence the stability of attitudes toward walking through puddles, mud or rugged spots on trails.

Table 3
Means of attitudes toward walking through any puddles, mud or rugged spots on the trail, rather than walking around them by pre-/post surveys and experimental groups.

	Control	Group 1			Group 2			F-value
	Post	Pre	Post	t-value	Pre	Post	t-value	
Good – Bad	−0.2 ^{ab}	1.1	1.4 ^{a}	−1.14	1.9	1.6 ^{b}	0.56	6.41**
Wise – Foolish	−0.3 ^{ab}	1.7	2.1 ^{a}	−1.69	1.9	1.4 ^{b}	1.65	7.82**
Pleasant – Unpleasant	−1.2 ^{a}	−0.4	−0.2	−1.23	0.1	0.5 ^{a}	−1.69	3.73*
Easy – Hard	0.3	0.6	1.1	−1.49	1.0	1.1	−0.32	1.21
Convenient – Tiresome	−0.2	0.2	−0.1	0.74	0.8	0.8	0.00	1.82
Necessary – Not necessary	−0.4 ^{ab}	1.6	1.8 ^{a}	−0.55	2.1	2.1 ^{b}	0.29	9.86***

Note: Post-survey means with same letter superscripts are significantly different at the 0.05 level. F-value was from ANOVA comparing three groups and t-value was from comparing pre-post score.
*** p-value < 0.001.
** p-value < 0.01.
* p-value < 0.05.

Table 4
Means of attitudes toward walking on wood or rock steps rather than around them by pre-/post surveys and experimental groups.

	Control	Group 1			Group 2			F-value
	Post	Pre	Post	t-value	Pre	Post	t-value	
Good – Bad	1.9	2.4	2.6	−1.00	2.6	2.5	0.29	1.62
Wise – Foolish	1.6 [a]	2.7	2.7 [a]	0.00	1.9	2.3	−1.86	2.96
Pleasant – Unpleasant	1.8	1.8	1.9	−0.68	2.1	2.0	0.52	0.11
Easy – Hard	1.6	2.0	1.8	0.85	1.9	1.6	0.79	0.10
Convenient – Tiresome	1.8	1.9	1.8	0.40	1.4	2.2	−2.55	0.55
Necessary – Not necessary	1.5	2.3	2.5	−0.94	1.9	2.3	−0.1.58	2.19

Note. Post-survey means with same letter superscripts are significantly different at the 0.05 level. F-value was from ANOVA comparing three groups and t-value was from comparing pre-post score. No F-value was significant.

4.4.2. Attitudes toward walking on wood or stone steps

In general, participants reported more positive attitudes toward the behavior of walking on wood or rock steps rather than around them (Supplementary Material C). The majority of all participants considered walking on steps good ($\bar{x}$= 2.4), wise ($\bar{x}$= 2.2), easy ($\bar{x}$= 1.7), necessary ($\bar{x}$= 2.1), pleasant ($\bar{x}$= 1.9) and convenient ($\bar{x}$= 1.9). Findings suggest different attitudes toward the two low-impact hiking behaviors. It is possible that individuals, particularly urban residents, are used to steps but not muddy trails. Thus, staying on steps seemed more familiar and appropriate to these participants.

No significant differences were found across the three groups in terms of participants' attitudes toward walking on steps rather than around them (Wilks' Lambda = 0.73, F (12, 78) = 1.09, p-value = 0.3835) with univariate analyses confirming these results (Table 4). Post-hoc comparisons identified only one significantly different pair between Group 1 and the Control group – participants in Group 1 considered walking on steps significantly wiser than those in the Control group. No differences were found between Group 1 and Group 2 on attitudes toward walking on steps rather than around them between pre- and post-survey (Wilks' Lambda = 0.72, F (6, 27) = 1.77, p-value = 0.1431; Table 4); this suggests differences in the timing of educational messaging did not influence participants' attitudes towards walking on steps rather than around them.

5. Discussion

This study tested the potential of integrating proactive off-site visitor education into landscape management and planning by examining whether or not the timing of an educational message influences compliance with low-impact hiking recommendations as well as associated knowledge levels and attitudes. We found receiving an off-site educational message increased participants' compliance with two specific low-impact hiking recommendations: 1) walking through puddles, mud or rugged spots; and 2) walking on trail steps rather than around them. Our educational message was able to effectively inform participants about low-impact hiking behavior and induce (or reinforce) participants' positive attitudes toward the two low-impact recreation behaviors. Neither their knowledge levels nor attitudes declined over the relatively short time period examined (1–3 days). The timing of the educational message did not significantly affect participants' compliance, knowledge level or attitudes.

The results of this study are consistent with the stable-attitude hypothesis (i.e., attitudes will stay stable over time after viewing/reading an educational message and, therefore, continue to influence behaviors), but are not consistent with the forgetting-curve hypothesis (i.e., over time, message recipients will forget the contents of an educational message, so their altered attitudes will not remain stable). It appeared our message did influence participants' knowledge and attitudes, and that influence remained stable. However, it is unclear if we achieved stability through a "central-route to persuasion" as described by the Elaboration Likelihood Model (Roggenbuck, 1992) or simply due to the possibility that time intervals of 24–72 h may not be long enough for any long-term effects (e.g., forgetting the message's content or variations in attitudes toward the behavior) to be discernable. However, from a managerial perspective, for natural areas that accommodate multi-day backcountry trips, 24–72 h may still be the best window to reach visitors prior to their trips. Within this window, visitors may still check their emails. In comparison, when individuals are in a vocation or travelling mode they may make a decision to not check their emails, or they may not have consistent Internet access especially if they are travelling to remote natural areas. Many online platforms and software systems, including the survey platform we used, allow land management agencies who maintain a pre-registration system to contact visitors via email following a preset schedule prior to their trips.

Other factors may also have contributed to the effectiveness of our educational message. The experiment was conducted in an educational setting, possibly making participants more receptive to persuasive messages. The effectiveness of the message may also have been partly due to the attention participants paid to the message, particularly for the participants in Group 2 who viewed the message in a controlled laboratory environment. Although the experiment administrator did not watch participants closely as they viewed the message, the presence of the researcher may have led them to pay particular attention to the message. Participants in Group 1 who viewed the message during their own time and at preferred location may also have felt a need to pay carefully attention to the message since they knew they would be coming to the lab to do tasks related to it. The knowledge questions administered after individuals view the video may reinforce participants' knowledge. It might enlarge the difference between treatment groups and control group. However, it should not influence the comparison between Group 1 and Group 2, as both groups were under the influence of knowledge questions; the only difference was the time interval between when they received the educational message and when they conducted the behavioral test. It is interesting to consider the knowledge questions as part of the educational messaging package, which included a video, statements, and questions. The questions could be designed as part of a game which may increase the appeal of a visitor education message.

The difference in compliance rates across trail conditions is also interesting. For the same type of trail degradation, the difference in compliances rates could be as high as 49.1% (Group 1 for muddy trail condition #1 versus muddy trail condition #4). The timing of educational messages seemed to exaggerate differences in responses to some trail conditions. The compliance rates for Group 2 (receiving the educational message immediately) were more consistent than those for Group 1 (receiving the educational message at least 24 h before the trip) across trail conditions. Unfortunately, we did not have enough data to statistically test the difference in variability. However, the underlining implication for interactions among landscape characteristics, recreation behaviors, and individuals' responses to visual representations of the landscape is worth pondering. For example, our images captured varied trail degradation severity levels. The severity level of degradation has been shown to be a significant predictor of individuals' behavioral intentions while hiking (Guo, Smith, Leung, Seekamp, & Moore, 2015). Trail condition #3 had the most mud in the photo, but trail condition #4 resulted in the lowest compliance rates across groups. Is it mostly characteristics of the landscape or elements of the image that affect individual responses or is the order in which the trail conditions were presented a factor as well? More studies are needed to address the interactions between landscape and human behaviors.

5.1. Managerial implications

Landscape management and planning is a systematic process that needs to consider a wide range of ecological and human factors. We propose that integrating proactive visitor education efforts into comprehensive landscape planning and management may reduce adverse recreation impacts and benefit natural resource conservation. This study supported the effectiveness of a proactive online visitor educational message in changing recreationists' hiking behavior. It is worth noting that creating and delivering an effective and well-designed online educational program is not an easy undertaking for recreation resource professionals. Successful online educational programs require extensive planning, programming, and quality visual design, given that they lack the benefits of direct personal contact and depend on visitors' willingness to engage with the material presented. Once the educational message is delivered, managers have less control compared to on-site educational programs. Managers may also need to allocate extra staff time to respond to comments and questions generated by their online educational materials. Some policy and management-related questions that need to be answered when developing such plans include: How much time does the manager expect visitors to devote to the education program? Should the online education become a requirement for certain types of recreation activities (e.g., backcountry hiking in bear habitat)? How should managers protect individuals' privacy in the process of educational communication? Should the public be able to directly reply to educational messages delivered via email?

To inform specific landscape and resource management strategies, this study demonstrated the benefits of using educational materials delivered to recreationists before they arrive at a setting. Our educational message focused on a small number of specific behaviors that have implications for visitor education program development. Commonly used low-impact recreation guidelines, such as Leave No Trace principles, are necessarily broad and designed to be applied in multiple contexts. The "best" recreation behavior could change dramatically based on the context (Marion, 2014). Such breadth and complexity of low-impact recreation behavioral recommendations present challenges to low-impact recreation education. An educational message that only focuses on broad principles may not be able to provide sufficient guidance for individuals to make environmentally responsible decisions, while an educational message focused on more specific behaviors may be more effective. Previous studies have noted the importance of specificity in educational message and program development (Bissix, Rive, & Kruisselbrink, 2009; Brown et al., 2010; Hughes et al., 2009).

5.2. Limitations and future research

In this study, we simulated a personal hiking situation and did not directly take social norms or group interactions into consideration. The effects of social norms, group interactions, and self-identity on behavior and attitudes change have been well documented in social-psychology (Bohner & Dickel, 2011; Miller & Prentice, 2016) and outdoor recreation studies (Cialdini et al., 2006; Widner & Roggenbuck, 2000). Future research should assess group interactions in terms of complying with low-impact recreation recommendations by differentiating the type of educational messages recreationists receive. A second limitation relates to social desirability; in other words, when participants report intentions to engage in desirable behavior but might not behave that way outside the context of the study. There have been mixed findings about how well self-reported recreation behavior matches individuals' actual behavior (Jett, 2007; Park et al., 2008; Reigner & Lawson, 2009). Unable to observe participants' actual hiking behaviors under degraded trail conditions in the field, we took several steps to reduce the influence of social desirability. First, we told participants this study was not a test or an evaluation and that they were not being graded based on their responses. Most participants responded to this instruction by smiling or nodding, suggesting an understanding that the study was focused on their actual behavioral intentions. Second, once the lab task started, the researcher moved to the side of the display facing the opposite direction from the screen to avoid participants feeling watched while they indicated their intended hiking behaviors. Participants rarely talked during the drawing task, suggesting they felt no need to justify their choices to the researcher.

We also acknowledge the limitation of our sample size, despite our efforts in recruiting participants. Initially a total of 121 students signed up for the study. We sent out six email reminders in a period of four weeks, which is frequent considering common online survey practices. We also asked instructors to remind their students to respond to the researchers' scheduling requests. Unfortunately, only half of the students followed through to full participation. This may have been due to the fact that the experiment was conducted two weeks before final exams. There were also two other experiments recruiting student participants at the same time competing for students' limited time and interest. Moreover, to comply with IRB requirements, study communications did not mention the extra credit opportunities that some instructors chose to provide. The small sample size for each treatment was not unseen in the low-impact recreation behavior literature (Trafimow & Borrie, 1999). It is worth noting that each participant reviewed seven trail condition photos resulting in a total of 329 behavioral intention observations. Participants and photos were added as random effects in the model to account for the shared variance within a participant and a trail photo. We suggest readers evaluate the inferential tests results (e.g., significance) based on their tolerance to type 2 error (e.g., failure to identify significant results).

Additionally, the nature of examining human behaviors in a laboratory-based setting should be seriously considered. The experimental research method has been well-established and widely used in psychology. However, it is acknowledged that individuals may behave differently in a laboratory setting compared to their behaviors in real life (Zelditch, 2007). Future studies could creatively design the laboratory setting to incorporate environmental factors and simulate situations when individuals need to trade comfort or convenience for responsible recreation. For example, study participants could be asked to stand with wet shoes or in a tub of snow while they draw the routes. The study could also be replicated on actual trails using tablet devices to mark where participants actually stepped. Moreover, Zelditch (2007) argued that the utility of experiments in social science studies lies in theory-testing. The resultant established theories could be used in more holistic ways to develop behavior change interventions and campaigns. Multiple theories and practical knowledge should be integrated into this process. The results from these practical applications should inform the validation and advancement of theories.

We consider this particular study the first step of this iterative process. We were able to support the stable-attitude hypothesis as opposed to the forgetting-curve hypothesis. To further test the effects of the timing of educational messages on behavioral change, the educational messaging package should be incorporated into agencies' and organizations' visitor education programs. The outcomes could be examined through on-site interview and feedback from frontline practitioners.

There are opportunities to expand and advance this line of inquiry. With larger samples, studies could include additional psychological factors such as personal norms, environmental attitudes, and place attachment. The influence of differential message timing could be more fully understood by examining longer time intervals. Future research could also address the question of how message complexity influences the retention of material presented. It would also be useful to examine how attention influences individual receptivity to low-impact recreation educational messages. A larger sample of prospective hikers who view the message on their own could reveal individual differences in attention levels and whether such differences might affect response to the messaging. It is also important for future work to implement field-based studies to test the effects of online educational programs, such as the one we used in this study, or existing Leave No Trace online awareness programs on observed hiking behaviors.

6. Conclusions

We found an educational message using video and written statements significantly improved participants' intentions to hike responsibly through muddy and wet trail areas and to stay on steps rather than walk around them, as well as improving their knowledge levels and attitudes toward such low-impact recreation behavior. A relatively short time interval between the educational message and the behavior measurement (24–72 h) did not change the effects of the educational message on behavioral intentions, knowledge, or attitudes. It is our hope that this study and related ones in the future will advance our understanding of low-impact recreation behavior change interventions and assist natural resource managers and researchers in their efforts to provide high quality outdoor recreation opportunities while protecting the landscapes upon which those opportunities depend.

Conflict of interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landurbplan.2017.03.013.

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