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Blending Multimedia and Face-to-Face Teaching to Enhance Learning about the Forest Floor

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Abstract

The forest floor is essential to functional, healthy forests. It is important for forestry professionals to understand, describe, and classify forest floors. We developed a Forest Floor educational resource, blending web-based multimedia and face-to-face teaching. The objectives of this study were to (1) develop blended-learning activities to teach forest floor description and classification and (2) assess student perceptions of the blended-learning method using exploratory factor analysis and group interviews. We used a Likert scale survey instrument to assess student perceptions of their learning, and investigated underlying factors through exploratory factor analysis of survey results and the manifestation of factors in focus group interviews. Five implicit factors were interpreted: (1) satisfaction with the Forest Floor resource as a learning enhancement; (2) response to presentation of concepts using a blended learning method; (3) student self-assessment of learning; (4) student learning preferences in accessing materials; and (5) website usability. Ninety-four percent of students agreed or strongly agreed that the Forest Floor resource was helpful for learning forest floor concepts, 79% that describing samples in class was essential for understanding the properties of organic horizons, and 81% that they were able to relate information in the Forest Floor resource to samples used in a face-to face activity, demonstrating that students tended to prefer learning information from videos and in collaboration with other students, and felt positive about their knowledge of the new material.

Core Ideas

- Forest floor is essential to forest ecosystems, but classification is difficult.
- Multimedia and face-to-face learning can teach visual tasks like soil classification.
- Students identified repeated visualizations and collaboration as important.
- Combining quantitative and qualitative methods of assessment gives deeper insights.

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The forest floor is one of the most distinctive parts of a forest ecosystem. It is composed of various vegetative parts (leaves, twigs, branches, bark, etc.) that are present at the soil surface and in various stages of decomposition. The forest floor is characterized by a great diversity of soil organisms and it plays an important role in carbon storage, nutrient cycling, and water retention. Although forest floor is reflective of overall forest site quality (Klinka et al., 1981), biodiversity, nutrient supply capability, and soil productivity (Ponge and Chevalier, 2006), learning about forest floor is not often part of university curriculum where the number of soil science courses is decreasing (Collins, 2008) or where soil science is becoming a required component of more generalized, integrative programs (Hansen et al., 2007). Because most post-secondary forestry programs still require at least an Introduction to Soil Science course (Collins, 2008), it is important that this course covers basic forest floor concepts and its role as a bridge between the aboveground, living vegetation and the soil. Repeated visualizations and hands-on experience are essential for learning about forest floor, and these can be addressed by a blended learning approach.

The present generation of post-secondary students has grown up with information and communication technology, and they handle digital information on a daily basis. They are connected to each other via mobile technologies, work interactively, and often perform several tasks simultaneously (Tapscott, 2008). According to Prensky (2001) and van Eck (2006), increased disengagement of the so-called "net generation" or "digital natives" from traditional instruction together with the ongoing popularity of digital technology have prompted interest in blended learning at both secondary and post-secondary levels. Blended learning involves integration of computer-mediated learning with face-to-face teaching (Owston et al., 2013). It has generally been thought that blended learning is more effective than face-to-face or online learning alone (Means et al., 2010), improving student satisfaction (Castle and McGuire, 2010) and grades (Cavanagh, 2011). Success of blended learning, however, depends on its integration

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Abbreviations: CFA, confirmatory factor analysis; CMS, content management system; EFA, exploratory factor analysis; ESL, English as second language; KMO, Kaiser-Myer-Olkin (Test of Sampling Adequacy); PAF, principal axis factoring; PCA, principal component analysis; UBC, University of British Columbia.

in the curriculum and one approach that lends itself to the implementation of blended learning is instructional scaffolding (Hogan and Pressley, 1997; Puntambekar and Hubscher, 2005). This scaffolding employs a variety of instructional techniques that move students progressively toward stronger understanding and greater independence in the learning process (Sawyer, 2006).

Blended learning provides opportunities to embed learning in authentic environments and thereby enhance engagement and learning outside traditional educational settings (Klopfer and Squire, 2008). Given the astounding complexity of natural ecosystems, it is crucial to develop educational approaches that can teach future land-planners and managers how to successfully solve the current global challenges such as climate change and declining species diversity. Using forest floor as an example of a complex natural ecosystem, we evaluated students' perception of their learning about forest floor through blending of online multimedia resources and face-to-face teaching.

To achieve this we: (1) developed a Forest Floor educational resource to teach forest floor description and classification, and (2) assessed student perceptions of their learning using exploratory factor analysis of an online survey, interpreted in light of responses during group interviews.

In psychological research, constructs are often not clearly defined in advance and investigators are not always certain of what will be measured (Browne, 2000). For this reason, the idea of latent or hidden variables that cannot be measured directly has arisen. These latent variables are determined by examining interrelationships between observed variables. Exploratory factor analysis (EFA) was initially developed more than a century ago (Spearman, 1904) and has subsequently become among the most commonly used procedures in psychological research (Fabrigar et al., 1999). Factor analysis is used to uncover latent variables (factors) that cause the manifest variables (items) to covary (Costello and Osborne, 2005). Shared variance is separated from the unique variance and error variance for each variable to uncover the latent constructs of those variables. Put another way, the latent constructs refer to the structure of correlations among the measured variables (Fabrigar et al., 1999). Rather than assessing each survey question individually, we combined quantitative and qualitative methods, conducting exploratory factor analysis of responses to the online survey to form factors based on shared variance among survey questions, and interpreting the emergent factors according to responses given during focus-group discussions with students.

MATERIALS AND METHODS

The Forest Floor educational resource consisted of a multimedia website (http://forestfloor.soilweb.ca/) and face-to-face teaching. The Forest Floor educational resource was implemented in a lower-level (second year) undergraduate course (Introduction to Soil Science) at the University of British Columbia (UBC), through instructional scaffolding (Sawyer, 2006) involving the introduction of the concept of forest floor, demonstration of how to describe and classify the forest floor, and provision of sufficient support to promote students' learning. The Forest Floor educational resource included a compelling task, an in-class lecture, online material (text, graphics, videos, animations), laboratory manual with templates and guides on how to describe forest floor, and face-to-face and online instruction. These aids were gradually removed as students developed independent learning strategies.

The overall expected learning outcome of the Introduction to Soil Science course offered by the university is for students to understand physical, chemical, and biological properties of soils, soil formation, classification, use, and conservation. During the 2014–2015 academic year, 232 students were enrolled in this course in two lecture sections (section 1 = 119 students, section 2 = 113 students), divided into eight laboratory sections (approximately 29 students per laboratory section).

Development of the Forest Floor Educational Resource

Creating the Forest Floor educational resource took about 1300 person hours and it involved ongoing consultations with a website developer, an educational multimedia producer, an educational expert, and three soil scientists to verify content accuracy and utility. Information presented in the Forest Floor educational resource is based on *Toward a Taxonomic Classification of Humus Forms* by Green et al. (1993) as well as *Taxonomic Classification of Humus Forms in Ecosystems of British Columbia* by Klinka et al. (1981); classification systems primarily focused on forest soils of the Canadian west coast.

The website of the Forest Floor educational resource was developed using WordPress CMS (Content Management System) and hosted on the university CMS. Video production involved a planning stage, 2 days of filming, production of motion graphics, and an editing stage. The video planning stage also involved collecting two differing forest floor samples, from the Malcolm Knapp research forest and the UBC farm, that were described on video. Video scripts were developed with the oversight of a soil scientist, an education expert, and an educational multimedia producer. Filming was done in the UBC soil science teaching laboratory and at the UBC farm. Videos featured a graduate student interviewing a forest soils expert (Dr. Margaret Schmidt) on-site, and each video had accompanying skeleton notes. An education expert provided oversight to ensure clarity of the information presented. The camera used was a Canon XF300 and sound recording was done with Sennheiser EW100 microphones. A graphic artist designed the graphics using Adobe Illustrator (Adobe Systems Inc., 2015) from photographs, drawings, and descriptions provided by the authors. Motion was added by another graphic artist using AfterEffects (Adobe Systems Incorporated, 2015). The voice-over was recorded at university studios. Video editing was done by the videographer using Final Cut Pro (FCPX) version 10.1.2 (Final Cut Studio, Apple Inc., Cupertino, CA).

The face-to-face teaching component of the Forest Floor educational resource consisted of an introduction to key forest floor concepts through classroom presentation and a laboratory manual, viewing of supporting forest floor videos and the Forest Floor website, hands-on descriptions and assessments of fresh forest floor samples in the lab, and completion of an assignment. The forest floor assignment was one of seven assignments in the Introduction to Soil Science course. Following the face-to-face activities, students had 1 week to complete and submit the assignment, certain questions of which required that students use the Forest Floor educational resource.

Before coming to the lab, students were encouraged to review the information provided in the laboratory manual and website. The lab manual allowed students to review information from paper-based text if that was their preference. Much of the information presented in the laboratory manual was adapted from the Forest Floor educational resource, though shortened to include only what was necessary for completion of the lab activities. Mor and moder samples, with Fm and Fa diagnostic horizons, respectively, were used during the campus-based laboratory sections. The samples were taken from the same site at the Malcolm Knapp Research Forest where the mor sample, used in the videos, was obtained. During the forest floor activities, students worked in groups of three to five to designate the F horizon (which was present in all samples) as either Fm, Fa, or Fz based on properties such as structure, roots, flora, and fauna type and classify humus form as mor, moder, and mull based on the diagnostic horizon.

Online Survey

The Forest Floor educational resource was implemented in the Introduction to Soil Science course during the 2014–2015 academic year and the 232 students enrolled in the course were asked to complete an online survey. The response rate was 34% (n = 79) and fell within the scope of acceptability for data analyses. The survey was modeled after design-based research principles (Wang and Hannafin, 2005), which provided participants with a complete disclosure of the survey intentions (i.e., quest description, its learning outcomes, and the overall study objective). As an incentive for students to complete the survey we offered the chance to win a gift card to a local coffee shop.

The online survey consisted of 39 questions (or items) and its completion was done on a voluntary basis on students' own time (i.e., not during a lecture or lab section). The survey opened 1 week after the forest floor activities were performed and after students submitted their assignments. The survey remained open for 7 days. Along with the survey questions, participants were asked to identify their program (major), year of study, lecture and lab section, and the reason for taking the Introduction to Soil Science course (options included: required course, personal interest, and other). The survey was created to assess students' perceptions of their learning and learning experiences, rather than assessing how much they learned or comparing student learning with the blended learning approach to other teaching methods.

Respondent Focus-Group Interviews

Seven focus-group interviews (each at about up to 8 minutes long) were conducted with the students in the Introduction to Soil Science course. The interview groups ranged between one and six participants. A total of 31 students participated in these interviews. The interviewer had a number of prepared questions, but whenever possible allowed the participants to lead the discussion and interact with one another in an open conversation about their experiences with the Forest Floor learning resource and activities. Comments from participants in the group interviews, especially those that express common sentiments among several participants, were taken to support interpretations of the factors arising from factor analysis and to help explain survey responses.

Psychometric Analysis

Analysis of survey results was conducted using SPSS Statistics software (IBM Corporation 2013). Items were tested first for correlation and correlations were tested for reliability and reliability if deleted. Two items, "I liked having access to the forest floor website while working on the lab assignment" and "Having access to the forest floor website while working on the lab assignment helped me to learn about the forest floor" were correlated with a correlation coefficient of 0.8, suggesting that participants responded as though the two items were very similar. The first item was removed from the survey, having a higher reliability if deleted.

Exploratory factor analysis (EFA), used to evaluate the structure of the correlations between items representing measured variables (Fabrigar et al., 1999), was chosen over principal component analysis (PCA) or confirmatory factor analysis (CFA). When there is not sufficient theoretical or empirical foundation to make assumptions as to the number of factors or what measured variable the factors may influence, EFA is preferable to CFA (Fabrigar et al., 1999). We used principal axis factoring (PAF), which has the advantages of making no assumptions as to the distribution of data, as well as being less likely to generate improper solutions (Finch and West, 1997). Exploratory factor analysis distinguishes between unique and shared variance, so that the values produced for variance accounted for by the factors are not overestimated (McArdle, 1990). Being less prone to generating a general factor compared with previous methods, Varimax rotation became popular and continues to be the predominant rotation appearing in psychometric studies (Browne, 2001). Varimax rotation forms new factor axes to produce correlation coefficients as close as possible to 1, 0, or −1 (Zeman et al., 2014). When interpreting each factor, we first examined the most strongly correlated items. The number of factors was determined based on the scree plot and item loadings.

The Kaiser-Myer-Olkin (KMO) Test of Sampling Adequacy and the Chronbach's Alpha for the reliability of the survey instrument were also determined from the data. Focus group interview responses are presented where they are considered relevant to the five factors interpreted, whether positive or negative. In many cases, students expressed similar sentiments in different focus group interviews and these are only presented where they are considered to add to our understanding of the factor.

RESULTS AND DISCUSSION

It is often recommended that the number of factors be determined from the scree plot, usually choosing a point where the slope of the curve flattens out. However, if the scree plot does not give a clear indication, it is necessary to compare the item loading tables after rotation for a range of numbers of factors (Costello and Osborne, 2005). The factor structure that best fits the data should have the fewest crossloadings, at least three items loading in each factor, and eigenvalues (representing the amount of variation accounted for by each factor) should generally be greater than 1. The scree plot (Fig. 1) shows how the first 11 possible factors all have eigenvalues above 1, and the slope of the curve levels off in several places (Factors 2, 4, 8, and 10). We chose to interpret five factors in an effort to balance accounting for as much variability as possible, while reducing the number of factors interpreted and ensuring each factor had a least three items loading.

There were no significant differences in online survey responses between lecture sections, lab sections, or students' year of study (data not shown). Based on the scree plot (Fig. 1), we chose to interpret five factors, all of which had at least three items loading. The KMO Test of Sampling Adequacy gave a value of 0.76. The case/item ratio was low (~2:1) and many studies have suggested minimum case/item ratios of 5:1 (Hatcher, 1994). However, the sampling adequacy value of 0.76 obtained in this study is a relatively strong value for psychometric research. The Chronbach's Alpha for the reliability of the survey instrument was 0.903 and all of the factors had Chronbach's Alphas above 0.6. The Chronbach's Alpha for the reliability of the survey instrument was 0.903 and all of the factors had Chronbach's Alphas above 0.6. The five factors selected accounted for a total of 46% of variability.

Sixteen items loaded on Factor 1 (Table 1), explaining 15% of total variance in responses. Factor loadings represent the proportion of shared variance between each item and the factor itself. Items that loaded more strongly (above 0.6 for Factor 1, and above 0.5 for Factor 2) are bolded in Tables 1 and 2, and we gave these items more weight when interpreting the factor. The items loading on this factor tend to refer to the benefits to students of having access to the Forest Floor website during the face-to-face activities and while working on the assignment. For this reason, this factor is referred to as "Satisfaction with the web-based educational resources as learning enhancement."

The statement "Having access to the website at any time and place was helpful for learning forest floor concepts," had a loading of 0.713, with 84% of respondents selecting agree or strongly agree. A number of previous studies have demonstrated how web-based tools can be used to reinforce learning by allowing students to repeatedly review content (Hoffmann and Ritchie, 1997; Moore and Gerrard, 2002; Polsani, 2003) and learning soil classification in particular requires repetitive review of material (Krzic et al., 2013). Such repetition and review, distributed over time, is necessary for long-term knowledge acquisition (Polsani, 2003; Ericsson, 2004). One participant in a focus group highlighted this, saying, "…if I did not understand something, I can go back many times. [In class] you can't ask to 'say again, and again,' I really liked that part." The concept of repeated review of material arose in several of the interviews. Another respondent stated, "I watched the videos again while I was doing the lab report. It really helped seeing it before, then doing [the sample description], then [seeing it] after." An English as second language (ESL) participant noted, "it was good to watch the videos. They didn't have subtitles, but I could still repeat so that I could understand." This suggests an added benefit of online material and multimedia over traditional instruction for students who have some difficulty following strictly auditory lectures. It may be advisable to include subtitles in future videos to ensure that all students can understand the material as well as possible.

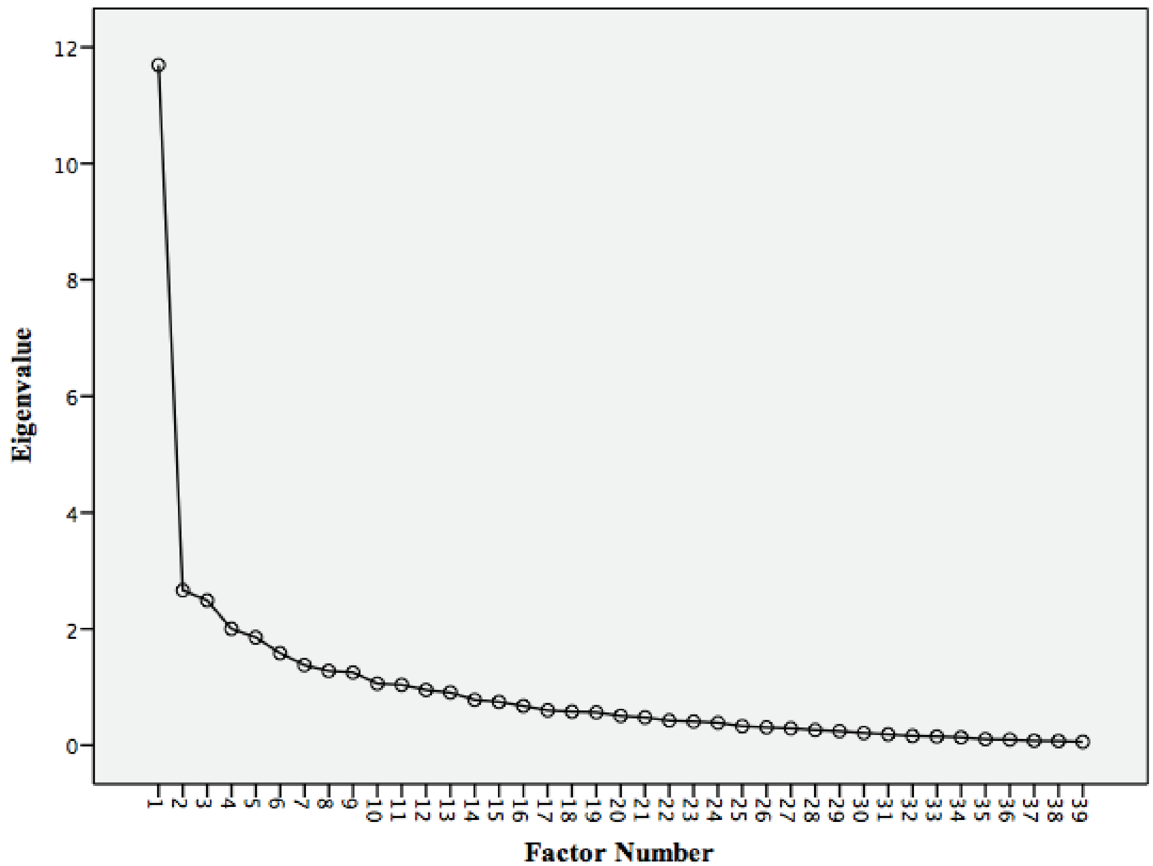

Fig. 1. Eigenvalues represent how much variance in all survey items are accounted for by each factor. The first factor accounts for the most variance in the survey items, and two "steps" occur with Factors 2 and 3, and Factors 4 and 5, before the curve becomes more consistent. We chose to analyze these first five factors because they each have at least three items loading and explain enough of the total variance (46%) to be of interest.

Table 1. Factor 1, satisfaction with the educational resource as a learning enhancement.

Statement	Loading	Strongly agree%	Agree%	Neutral%	Disagree%	Strongly disagree%
Having access to the website at any time and place was helpful for learning forest floor concepts	**0.71**†	38	56	4	3	0
I found having access to skeleton notes while reviewing the videos helped me to identify important points	**0.68**	23	52	23	1	1
Having access to the forest floor website while working on the lab assignment helped me to learn about the forest floor	**0.67**	53	41	5	0	1
I thought that the in-class portion of the lab was complemented by the addition of the forest floor website	**0.64**	27	51	19	3	1
I thought the website was aesthetically pleasing overall	**0.64**	30	53	14	3	0
Combining multimedia and web-based elements with in-class learning was beneficial to my learning	**0.61**	34	52	14	0	0
I could have learned the material equally effectively without the use of multimedia and web-based elements	0.59	8	39	39	14	0
I did not find the forest floor website helpful in learning about the forest floor	0.52	47	41	10	1	1
After completing the forest floor lab and assignment with the help of the website, the properties of different organic horizons are still not clear to me	0.52	5	15	20	54	5
I found that the multimedia elements presented on the forest floor website reinforced what I learned during the forest floor lab	0.48	18	65	16	1	0
Graphics and images on the website and in videos helped me to visualize key elements of the forest floor	0.44	25	58	15	1	0
Graphics and images on the website and in videos did not improve my understanding of the forest floor	0.43	20	59	13	5	3
After completing the forest floor lab and assignment with the help of the website, I feel confident differentiating between the organic horizons (L, F, H, and O)	0.43	14	49	27	9	1
I thought too much information was presented in the forest floor videos	0.37	16	53	20	9	1
Using the website to learn the material made me feel isolated from other students and/or my instructor	0.35	33	53	9	5	0

† Bold numbers represent items that loaded more strongly (above 0.6 for Factor 1, and above 0.5 for Factor 2). Loadings represent how strongly each item is correlated to the factor istelf.

Table 2. Factor 2, success of presentation of concepts using blended learning method.

Statement	Loading	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Describing the forest floor samples in the laboratory was essential to my understanding of the properties of the different organic horizons	**0.74**†	19	59	19	3	0
I was able to relate the information in the videos and on the website to what we were seeing in our sample in the lab	**0.67**	20	58	18	4	0
The forest floor lab and website taught me the differences between the decomposer communities in the different humus form orders	**0.63**	13	59	19	4	5
I found it difficult to make connections between the information presented in the forest floor videos and on the website with what we saw in our lab samples	**0.57**	13	59	14	11	3
The forest floor lab and website effectively introduced me to the humus form orders (mor, moder and mull)	0.49	32	52	13	4	0
After completing the forest floor lab and assignment with the help of the website, I understand the impacts of the forest floor on soil properties	0.46	13	70	16	1	0
Describing and classifying the humus form in the laboratory was necessary for me to understand the properties of the different humus forms	0.45	13	68	16	3	0
The forest floor lab and website effectively explained the chemical properties of different types of litter to me	0.44	11	54	29	5	0
The forest floor lab and website effectively communicated the importance of the Forest Floor in forest ecosystems and soils	0.43	25	61	11	3	0
I think that the forest floor videos did not provide enough information	0.31	8	54	28	10	0

† Bold numbers represent items that loaded more strongly (above 0.6 for Factor 1, and above 0.5 for Factor 2).

During focus-group interviews, students tended to respond positively to the amount of information presented in the videos, although, one student noted that they found "watching a whole video and picking out information [was] hard," preferring reading text to watching the videos. Maintaining short video lengths, identifying key words with text labels, and providing skeleton notes all aim to reduce this difficulty, but alternative sources of information are necessary to ensure that all students can approach learning in the best possible way.

The statement, "Having access to the forest floor website while working on the lab assignment helped me to learn about the forest floor," had a loading of 0.627, with 95% of respondents selecting agree or strongly agree. The design of the forest floor website aimed to maximize student engagement with the material. Tuthill and Klemm (2002) have noted how complexity in the organization of a website encourages students to explore information independently, leading to novel idea associations and greater learning. Variability in the medium of information presentation on each page and across the site, including video, text, photographs, graphics, and tutorials, can help to maintain student interest in the online teaching resources (Cox and Su, 2004), and to cater to a variety of learning styles (Jain and Getis, 2003).

When asked if the Forest Floor web-based multimedia resource was helpful in completing the assignment, one respondent replied simply, "Yes, very much," while another elaborated, "I think the website is good enough to finish the assignment. I found all the information for the assignment on the website." In another focus-group interview, one participant commented, "…this course is really intensive for me, so having a place where we can find what we need was really helpful." A second agreed, saying that they thought "the website was a better design than the textbook. It was very good for me."

The statement, "I thought that the in-class portion of the lab was complemented by the addition of the Forest Floor website," had a loading of 0.641, with 80% of respondents selecting agree or strongly agree. A similar statement, "Combining multimedia and web-based elements with in-class learning was beneficial to my learning," had a loading of 0.611, with 84% of respondents selecting agree or strongly agree. The blended learning model can improve student satisfaction (Castle and McGuire, 2010) and has generally been considered more effective than classroom or online learning alone (Means et al., 2010). During the group interviews, a participant specified that "watching the videos" was most useful during the lab for learning how to identify the organic horizons and humus form orders. Another student elaborated, saying "I think it helped a lot because, the soil is too similar, it's hard to know right away what are the differences." Other students noted the importance of seeing the forest itself, with one participant stating, "I think that the video was able to give the topic more relevance and that it was a more efficient use of time. It shows where the forest is, before we looked at the samples." This was echoed in another focus group, where a participant said, "I like your videos because they were filmed in the field, so you could see what it really looks like."

The statement, "I thought the website was aesthetically pleasing overall," had a loading of 0.638, with 84% of respondents selecting agree or strongly agree. Some students commented positively on the aesthetic of the website, including one stating, "I liked that it was a pretty website…very nice designs." Although another student commented that they found the look of the website to be "basic." Aesthetics can be an important determinant of users' evaluation of a website, as impressions are formed in the first moments of exposure to a website and these impressions are maintained over time (Lindgaard et al., 2006). Furthermore, a positive initial aesthetic impression instills in users a positive expectation of the website (Tractinsky et al., 2006).

Ten items loaded on Factor 2 (Table 2), explaining 12% of total variance. The items loading on Factor 2 tend to refer to how well concepts were presented using the blended learning model and the relate-ability of information presented on the website (in particular the videos) to the face-to-face teaching. For this reason, Factor 2 is referred to as "Response to presentation of concepts using a blended learning method."

The statement, "Describing the forest floor samples in the laboratory was essential to my understanding of the properties of the different organic horizons," loaded at 0.736, with 79% of respondents selecting agree or strongly agree. Having the opportunity to examine the forest floor samples, while engaging their senses of vision, touch, and even hearing gave students deeper insight into what they saw in the videos and read in their laboratory manuals. As Udovic et al. (2002) show, this can provide significant benefits for learning in science. According to Piaget (1971), we learn best during active application of the ideas and concepts that are being presented to us. This is supported by a number of student comments in focus-group interviews. One participant stated, "A lot of the time I find that when I look at a definition, I have no idea what it is, but then when I look at the hands-on, it's like 'Oh, of course'." Another student in the same interview agreed, saying, "Once you pull stuff apart you kind of realize, 'that's what the definition means'." A third student, when asked during the interview for their thoughts on the hands-on aspect of the laboratory, replied, "It was more fun. It was more like I'm actually learning from it. The sample is better than just sort of memorizing. More hands on experience, everything hands on—I learn better." The fact that the face-to-face laboratory was enjoyable came up again in another response, "It was really fun pulling the samples apart, to get your hands dirty."

Students have a desire for collaborative, active learning (Bekebrede et al., 2011) that requires discussion and building of consensus (Lal, 2010). Such collaboration gives students deeper insights into the concepts they are learning (Udovic, 1998), as they need to persuade their peers that their opinions are well founded (Peterson and Jungck, 1988; Prunuske et al., 2012). The face-to-face teaching and learning provides students with a sense of community and engagement with other students (Collopy and Arnold, 2009). In one of our interview groups, a student said, "I was in a group with four people. We often have differing ideas on how much of a property is a lot, how much is a little, because we'd never looked at a forest floor sample before. It was important to have a group." Another student agreed, "I think it was good to work in a group, sometimes we would end up discussing and have to review the definitions. I couldn't just say, 'this is what it is'. I had to justify it. In the group setting you have to justify your views, you actually have to use the vocabulary that you learned to express yourself."

Table 3. Factor 3, student self-assessment of learning.

Statement	Loading	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
After completing the forest floor lab and assignment with the help of the website, I still feel unsure about the differences between the humus form orders	0.66	9	42	27	22	1
After completing the forest floor lab and assignment with the help of the website, I feel confident differentiating between the organic horizons (L, F, H, and O)	0.59	16	57	23	4	0
After completing the forest floor lab and assignment with the help of the website, I do not feel comfortable explaining ways the forest floor influences soil properties or impacts the forest ecosystem	0.58	11	42	33	14	0
I believe that what I learned from the forest floor lab and assignment is important knowledge for forest management	0.44	39	47	13	0	1
The forest floor lab and website effectively introduced me to the properties of organic horizons (L, F, H, and O)	0.43	43	54	3	0	0

Although students generally regarded learning collaboratively in groups as a positive experience (Bekebrede et al., 2011), there were some negative comments regarding group sizes, dominance of particular group members during discussions, and a lack of participation on the part of other group members. During the forest floor activities, students were encouraged to work in groups of five. One participant in the focus-group interview stated that their initial group of five was too large: "When there are five hands in one sample it doesn't really work. Afterward, we split up and it was a lot easier." Two participants who had worked together on the activity explained that they had a group of seven students working on one sample; however, two of the seven had not participated in the discussion but instead "[sat] behind us and [copied] us." Other participants in the focus group compared their experiences, describing their group of four as the "perfect" number. In addition to the copying complaint, a participant in another focus group interview brought up the difficulty with expressing differing opinions in a group where certain students were dominating the discussion. Another participant agreed, saying "It is important for everyone in the group to discuss and tell everyone what they think…it's not good if you don't feel like you are participating in it." The participant continued, echoing a sentiment in other focus groups, "I think smaller groups can be better."

The statement, "I was able to relate the information in the videos and on the website to what we were seeing in our sample in the lab," loaded at 0.671, with 81% of students selecting agree or strongly agree. A negatively worded statement of a similar nature, "I found it difficult to make connections between the information presented in the forest floor videos and on the website with what we saw in our lab samples," loaded at 0.573, with 76% of students selecting disagree or strongly disagree. The blended learning model allows students to make associations between the information presented with multimedia and online technologies and their experiences in face-to-face learning. Improved learning and better retention of material results when students engage in active construction of their knowledge (Knight and Wood, 2005). This agrees with the positive response of students in our study to how information was presented and the benefits of blended learning in promoting collaboration. One student provided examples of how their group related information presented in the videos to their forest floor sample, saying, "[the video] mentioned that for a specific horizon you pull the roots and you can hear them being pulled apart. Or when you touch the H [organic horizon] it will leave a stain on your hands. I think that helped." Another student explained how the videos provided an advantage compared with text, "Often I find when I read things, I have to read it at least a few times for me to be able to come up with a visualization… When it's a video, you can see that first hand."

Five items loaded on Factor 3 (Table 3), explaining 8% of total variance. The items loading on Factor 3 tend to reflect students' assessments of their own learning of the information presented by the forest floor activities; hence, this factor is referred to as "student self-assessment of learning." Factors 2 and 3 demonstrate that students responded positively to questions regarding learning objectives (Tables 2 and 3).

The statement, "After completing the forest floor lab and assignment with the help of the website, I still feel unsure about the differences among the forest floor types," loaded at 0.66 with 51% of students selecting disagree or strongly disagree (25% of students selected agree or strongly agree). The statement, "After completing the forest floor lab and assignment with the help of the website, I feel confident differentiating between the organic horizons," had a loading of 0.592, with 73% of students selecting agree or strongly agree. The statement, "After completing the forest floor lab and assignment with the help of the website, I do not feel comfortable explaining ways the forest floor influences soil properties or impacts the forest ecosystem," had a loading of 0.578, with 48% of students selecting disagree or strongly disagree (17% selected agree or strongly agree). Drawing on constructivist learning theory, blended learning gives students more control over what material they access and at what pace they review material—allowing them to concentrate on material they find difficult and move quickly through material they understand easily (Cook, 2007). Students value the ability to choose between different learning mechanisms to best suit their learning needs, and appreciate the flexibility in time and place allowed with online learning (Mitchell and Forer, 2010). One student explained, "We could visualize what you guys did on video and then apply it to what we were doing [in the laboratory] so that it was easier to identify the forest floor types." Referring to the different decomposer communities in relation to the forest floor type, another student said, "The decomposer part is [harder] to memorize for me—whether you have fauna or fungi—I think it's very clear on the website."

Table 4. Factor 4, student learning preferences in accessing materials.

Statement	Loading	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I found the videos to be the most useful medium for learning about the forest floor	0.63	24	42	20	14	0
While working on the forest floor lab and assignment, I preferred learning from reading text rather than watching video clips	0.62	3	23	33	32	10
I found videos and graphics to be more effective than plain text in learning about the forest floor	0.59	35	41	20	4	0
Learning with the aide of the website was preferable to using a textbook or lecture notes	0.31	23	47	27	3	1

Four items loaded on Factor 4 (Table 4), explaining 6% of total variance. The items loading on Factor 4 referred to student preferences regarding how they accessed learning materials to learn the topics presented in the forest floor activities. For this reason, this factor was referred to as "Student learning preferences in accessing materials."

The statement, "I found the videos to be the most useful medium for learning about the forest floor," had a loading of 0.634, with 66% of students selecting agree or strongly agree (15% selected disagree). The statement, "While working on the forest floor lab and assignment, I preferred learning from reading text rather than watching video," had a loading of 0.624, with 28% selecting agree or strongly agree, and 42% of students selecting disagree or strongly disagree. The statement, "I found videos and graphics to be more effective than plain text in learning about the forest floor," had a loading of 0.594, with 88% of students selecting agree or strongly agree.

Several studies have shown that the inclusion of varied multimedia material into course content improved student learning by providing a variety of viewpoints and supporting different learning styles (Hoffmann and Ritchie, 1997; Moore and Gerrard, 2002; Polsani, 2003; Cox and Su, 2004). Even distribution of visual media among web pages can help to maintain students' interest as they explore the online learning resource (Jacobson et al., 2009). The majority of students interviewed in this study identified both videos and supporting text as important, but accessed the material in different ways. For example, one student said, "You can get more in depth with the [written] part, and then watch the video to see in general and understand all the components." Another student took an opposite approach, saying, "The reading was more in depth than the videos, so after I watched the videos, if that wasn't enough then I could read to supplement that." One student enthusiastically acknowledged the tutorial page as the most helpful for completing the assignment, explaining, "I was really stoked on this assignment. It helps you find the answers. I told people afterward, they're all on the website."

Three items loaded on Factor 5 (Table 5), explaining 5% of total variance. The items loading on Factor 5 refer to students' positive response to the multimedia and web-based elements and website navigation. For this reason, this factor is referred to as "Website usability." The statement, "I could have learned the material equally effectively from the multimedia and web-based elements alone," had a loading of 6.84, with 41% of students selecting agree or strongly agree, and 28% of students selecting disagree or strongly disagree (Table 5). The large number of students who selected agree or strongly agree to this statement is somewhat surprising, given how many also expressed appreciation for the importance of the face-to-face laboratory activities. It is possible that students may have been referring, in particular, to the usefulness of the website and videos for answering the assignment questions or preparing for final exam questions.

The statements, "I found it difficult to find the specific information I was searching for on the website" and "I found navigation of the website to be self-explanatory," had loadings of 0.457 and 0.373, and 23 and 76% of respondents selecting agree or strongly agree, respectively. The success of student learning experiences with blended learning is dependent on the quality of the online resources being used, requiring the collaboration of experts both in the technological and curricular aspects of content development (Garrison and Kanuka, 2004). Even minor problems with a website can decrease satisfaction, participation (Cook et al., 2005), and increase cognitive load (Sweller, 2005). Navigation problems, such as non-functional external web links, can lead to significant student dissatisfaction with a web-based learning tool (Oliver and Omari, 2001).

The majority of our students did not have difficulty exploring the website, but there were students who had difficulty finding particular information. For example, one student said that, "it was easy, because you actually gave instructions on where the right page [was] to answer the questions," while another in the same focus group stated that they, "had a hard time finding stuff on the website." A number of studies have suggested that nonlinear website organization compels students to explore independently, and thus improves learning (Tuthill and Klemm, 2002; Jacobson et al., 2009). The design of the forest floor website aimed to maximize student engagement with the material. Variability

Table 5. Factor 5, usability of the educational resource.

Statement	Loading	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I could have learned the material equally effectively from the multimedia and web-based elements alone	0.68	1	27	34	34	4
I found it difficult to find the specific information I was searching for on the website	0.46	10	46	22	20	3
I found navigation of the website to be self-explanatory	0.37	29	44	19	8	0

in the medium of information presentation on each page and across the site, including video, text, photographs, graphics, and tutorials, can help to maintain student interest in the online teaching resources (Cox and Su, 2004) and cater to a variety of learning styles (Jain and Getis, 2003). Although problems with the functionality of a website or other unnecessary complications that can discourage students should be avoided, the potential learning benefits of student "construction of knowledge" make a somewhat complex website design, requiring exploration, preferential.

CONCLUSIONS

There is an ongoing need for forestry and land resource professionals with a solid understanding of importance of soil and forest floor within the forest ecosystems. One approach for acquiring this knowledge is to enhance current post-secondary curriculum by blending face-to-face teaching with web-based multimedia resources. The Forest Floor educational resource was developed to help meet the challenge of educating the "net generation" of students as future forestry and land resource professionals.

Responses to the online survey and during focus-group interviews were predominantly positive and demonstrate that learning objectives were met by using a blended learning approach. Exploratory factor analysis gave us the opportunity to investigate the factors underlying students' positive responses to the blended learning approach. Interpretation of the implicit factors was supported by focus-group interviews with students. The five factors that we interpreted include: satisfaction with the Forest Floor educational resource as a learning enhancement (Factor 1), response to presentation of concepts using a blended learning method (Factor 2), student self-assessment of learning (Factor 3), student learning preferences in accessing materials (Factor 4), and website usability (Factor 5). The majority of students agreed or strongly agreed that the Forest Floor educational resource was helpful for learning forest floor concepts (94%), describing samples during face-to-face activities was essential for understanding the properties of organic horizons (79%), and they were able to relate information in the videos and on the website to their own samples (81%).

Using a blended learning method gave students control over their learning and allowed them to connect web-based information to soil samples examined during face-to-face activities and assignment questions. Student responses highlighted the importance of, as one focus-group participant put it, "getting your hands dirty," along with the advantages of working in a group, participating in discussion, and using appropriate terminology. The study demonstrates that adapting curriculum to suit the learning preferences of contemporary post-secondary students with a blended learning approach can successfully teach challenging concepts such as forest floor description and classification.

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