A Comparative Analysis of Online Learning Materials Aimed Toward Integrating Great Lakes Science Into the K-8 Classroom

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ABSTRACT

We surveyed the use of Great Lakes online learning materials by a sample of K-8 teachers. Analyses tested for correlation of use with 1) whether teachers learned about the resources in pre- or in-service education, 2) geographical significance, and 3) whether teachers taught about the topics emphasized in the online learning materials. We compared findings for the Great Lakes to an ocean resource (BRIDGE) and more general Earth System Science online learning materials. Teachers reported using the Internet for teaching and planning. However, very few teachers reported using Great Lakes materials, BRIDGE, and most of the generalized online learning materials. The exception was the National Oceanic and Atmospheric Administration National Weather Service webpage, used by >50% of respondents. Teachers who learned how to use online learning materials in pre-service or in-service education were more likely to use them in-service. There was no significant effect of geographic proximity to the Great Lakes or ocean on the likelihood that a teacher used particular materials. Teaching about the Great Lakes was a necessary, but not sufficient condition for using Great Lakes online learning materials. The results indicate that teacher education is a key to inclusion of specific online learning materials in K-8 education.

INTRODUCTION

The National Science Education Standards (NSES) (National Research Council (NRC), 1996) and the American Association for the Advancement of Science Benchmarks for Science Literacy (AAAS) (1993) emphasize Earth System Science (ESS) as an important component of elementary science education. The NSES discuss the earth as a system (NRC, 1996) and this approach is defined by Meeson (2000) as "studying the processes and interactions (cycles) among the atmosphere, hydrosphere, cryosphere, biosphere, and geosphere from a global to local point-of-view, and across the time scales (minutes to eons) in which these spheres interact." The national standards documents outline broad concepts for ESS, such as "Water…condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soils, and in rocks underground" (NRC, 1996, p. 160). Yet, the NRC also suggests that broad, generalized and abstract concepts should be grounded in concrete examples and experiences (NRC, 2005, p. 37). One role of teachers is to incorporate into instruction concrete applications and contexts of generalized principles and concepts. (Such contextual background knowledge may be particularly important for meeting the needs of children in poverty (Neuman 2006a, b)).

A concrete context for many ESS concepts dealing with weather, oceanography, and watersheds is the North American Great Lakes (hereafter "Great Lakes"). For example, to teach about the NRC standard regarding precipitation quoted above, lake-effect snow provides an excellent example that is critically important in many U.S. states. The use of the Great Lakes in ESS education may be even more powerful when the topics are locally important to children. The NRC (1996) gives an example that "in Cleveland, the study of Lake Erie, its pollution, and cleanup is an important part of a science curriculum…" (p. 31). This methodology is supported in the NSE Teaching Standard A, which states that teachers must "select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of children" (NRC, 1996, p. 30). Thus, whether it be as a concrete example of key ideas (such as the effect of large bodies of water, like the Great Lakes, on precipitation) or as a localized point of interest, teaching about the Great Lakes is useful in ESS education in North America.

There are other specific and concrete contexts for generalized ESS principles, some of which have particular local interest. For example, the arid eastern areas of the states of Washington and Oregon are examples of important rain shadows. A study focusing on aspects of Great Lakes ESS education may yield insights that are transferable to other aspects of ESS education.

This study is concerned with resources that elementary teachers need to effectively teach about ESS topics. The Great Lakes resources offer a useful case study, because a good deal of effort has been allocated into developing such resources. For example, many of the principles and concepts relating to Great Lakes ESS topics are found in the *Essential Principles of Ocean Literacy* (Ocean Literacy, 2005) (though these principles and concept focus more on marine than freshwater systems). More have recently been suggested in a draft of Lake Erie Literacy Principles and Concepts (2009). One recommendation for providing teachers with the resources they need to support this subset of ESS principles and concepts comes from the *Conference on Ocean Literacy Report* (National Marine Sanctuary Foundation, 2006): "evaluate, and then develop and/or revise, curricular materials based on "sound-science," and align these resources with *The Essential Principles and Fundamental Concepts of Ocean Literacy,* state standards, and the National Science Education Standards." Though ostensibly a document about marine science, this recommendation holds for the *Essential Principles and Fundamental Concepts of Ocean Literacy* that are applicable to the Great Lakes, as well as other, aligned documents

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such as the Lake Erie Literacy Principles and Concepts. In fact, many such curricular materials are available, particularly through Internet access. Several highlighted in this study are described in Table 1.

This study exclusively focuses on online learning materials, defined here as simulations, animation, tutorials, drill and practice, quiz/test, lecture/ presentation, case study, collection, reference materials, learning object repositories, online courses, and workshop and training materials (MERLOT, 2007; Malloy and Hanley, 2001), as well as lesson plans, classroom activities, and platforms for children's collaborative research (e.g., the Center for Innovation in Engineering and Science Education's "Collaborative Projects" <http://www.ciese.org/collabprojs.html>). This definition excludes complete curricula as are commonly marketed in the form of textbooks and science "kits". This study focuses on a subset of ESS online learning materials: those dealing with Great Lakes science.

The study also considers a comparison group of online learning materials that focus on the ocean and more generalized ESS topics (Table 1). While the authors recognize that a number of good quality online learning materials are available to educators through a variety of federal (e.g., U.S. Geological Survey) and state government and non-profit organizations, for the purposes of this study, we focused on the representative sample of online learning materials.

RESEARCH QUESTIONS

Some information exists about the use of specific ESS online learning materials, but this is limited primarily to download statistics. For example, Michigan Sea Grant's Fisheries Learning On the Web had more than 9,500 curriculum materials downloaded and over 155,000 hits to curriculum pages were tracked during the 2007-2008 fiscal year. Other than this, little is published about teachers' use of ESS online learning materials. Thus, interested parties have little or no information regarding whether teachers use these online learning materials and what factors predict whether or not teachers use particular online learning materials. Interested parties include, but are not limited to those who develop the materials and those who are interested in quality instruction focusing on the topics on which these materials focus.

First, this study asks whether and how often teachers in grades K-8 use online learning materials that focus on Great Lakes science. This descriptive question is, to our

TABLE 1. ONLINE LEARNING MATERIALS THAT WERE THE FOCUS OF THE STUDY

Focus	Online Learning Material	Description
Great Lakes	Fisheries Learning on the Web (FLOW) – Michigan Sea Grant	collection of lessons and activities about the Great Lakes ecosystem, fisheries and stewardship - Fisheries Learning on the Web
	NOAA-GLERL Outreach - Great Lakes Environmental Research Laboratory (GLERL)	Inform[s] constituents of the lab's scientific products, services, and expertise and provide[s] access to such resources as needed - GLERL Outreach
	teach.GLIN.net - Great Lakes Information Network and the Great Lakes Commission	"virtual library" of curriculum and related educational materials, as well as an educators information exchange corner - teach.GLIN.net
	COSEE Great Lakes curriculum resources - Centers for Ocean Sciences Education Excellence	foster[s] the integration of ocean research into high quality educational materials - COSEE Great Lakes
Ocean	BRIDGE - Sea Grant Ocean Sciences Education Center	selection of the best online resources for ocean sciences education - NOAA Education: Advancing Environmental Literacy webpage
General Earth System Science	The GLOBE Program	worldwide hands-on, primary and secondary school-based science and education program - promotes and supports students, teachers and scientists to collaborate on inquiry-based investigations of the environment and the Earth system- The GLOBE Program
	Elementary GLOBE -The GLOBE Program	introduce[s] K-4 students to the study of Earth System Science (ESS) - Each Elementary GLOBE module contains a science based storybook and classroom learning activities - Elementary GLOBE
	UCAR Education - The University Corporation for Atmospheric Research	collaborative tools for the atmospheric & Earth system science community - resources for students, educators, and professionals -UCAR
	NOAA – National Weather Service (NWS) Weather Education/Outreach	information about weather education and outreach – NOAA
	NOAA Education	designed to help students, teachers, librarians and the general public access the many educational activities, publications, and booklets that have been produced – NOAA
	Digital Library for Earth System Education (DLESE)	electronic materials for both teachers and learners, such as lesson plans, maps, images, data sets, visualizations, assessment activities, curriculum, online courses– DLESE

knowledge, unanswered for most ESS online learning materials and, specifically, Great Lakes learning materials, despite the efforts of various groups and agencies to develop these resources. The answer to this question with regard to the Great Lakes materials is more meaningful if compared to the use of other online learning materials. A brief review of state educational standards did not find substantial inclusion of Great Lakes science. For this reason, we compared our findings for the Great Lakes to an ocean online learning material (Table 1), as ocean topics are better representation in national and state standards (Schoedinger et al., 2006). Also, a comparison is made to more general ESS online learning materials (Table 1), which support topics included in most state elementary science education standards.

Preliminary analysis made obvious that the use of Great Lakes online learning materials was not common. Thus, one future goal might be to increase the use of these online learning materials. To inform these efforts, we asked if teachers' pre-service and in-service education about specific online learning materials predicted their use of the materials. We chose this factor as a focus, because it is one that interested parties might reasonably influence. However, other factors, beyond the control of interested parties, might also influence the use of online learning materials, potentially overwhelming any effect of teacher education. To address all likely influences on classroom behavior in a multivariate design requires a dataset and resources well beyond the scope of this study (e.g., Banilower et al., 2007). Instead, we focused on two likely influences on the use of specific online learning resources: geography and whether teachers included the topics supported in the materials in their realized curriculum. One prediction was that teachers living near to the Great Lakes or the ocean may use online learning materials specific to these natural features, as they adapt the curriculum to meet the needs and interests of the children in their classroom. A second prediction was that teachers who teach about the Great Lakes or ocean might tend to use Great Lakes or ocean online learning materials. This prediction is couched in the understanding that the choice of classroom curriculum topics is influenced by a variety of state and local factors including state standards, administrative decisions, as well as teachers' decisions (Remillard, 2005), and, thus, somewhat out of the direct influence of developers of online learning materials and other interested parties.

METHODS

This study was conducted between May 28 and July 19, 2008. The instrument was an online questionnaire. A survey instrument was developed, because a review of the literature did not produce established instruments pertaining to the research questions. The instrument followed the format and, whenever possible, the wording

TABLE 2. SURVEY QUESTIONS ANALYZED IN THIS STUDY

Topic	Questions and Prompts
Demography	• Gender • Ethnicity • Age • How many years have you taught prior to this school year?
Geographic proximity	How near are you to: • The nearest saltwater (ocean, bay, harbor, gulf, sound, etc.)? • The nearest Great Lake (i.e., Lake Superior, Michigan, Huron, Ontario, or Erie)?
Habitual educational use of the Internet	About how often do you use the Internet for each of the following tasks? • Obtain information related to subjects being taught • Get ideas for instructional aids, activities, and lesson plans • Get ideas for new teaching methods
Frequency of teaching about the Great Lakes and ocean	Question asks about teaching in all subject areas. If you teach multiple sections or classes, please answer for your first class of the week. About how often do you teach about each of the following in this class? • The Great Lakes (Lakes Superior, Michigan, Erie, Huron, or Ontario) • The Ocean
Education about Earth System Science online learning materials	Please indicate whether you learned how to use the following resources during your undergraduate education, graduate education, In-service education, or workshops (see Table 1).
Use of Earth System Science online learning materials	Question asks about your Science, Earth Science, Geography, and Social Studies teaching. If you teach multiple sections or classes, please answer for your first class of the week in which you teach Science, Earth Science, Geography, or Social Studies. About how often do you use information or activities from each of the following during you instruction in this class? (see Table 1)

of the *Local Systemic Change through Teacher Enhancement Science (LSC)* 2006 Questionnaire (Horizon Research, 2000). Items regarding demography were based on the *LSC 2006 K-8 Questionnaire* (Horizon Research, 2000), with slight modification. Portions of a larger instrument were considered in this analysis (Table 2). A group of science education experts, teachers, non-education professionals, and editors with experience in editing for the general public reviewed the questionnaire for validity and readability. Changes to wording occurred following these reviews.

The use of an online questionnaire ensured that teachers responding to the survey were at least familiar with the Internet, a prerequisite for making use of online learning materials. Nonetheless, it was anticipated that particular demographic groups of teachers may be more or less likely to utilize online materials for teaching, and this background may influence the use of online learning materials geared toward Great Lakes science. Thus, an *Internet Use for Lesson Planning* composite score was calculated from three response items from Alghazo's (2006) 28-item survey on the frequency of using the Internet for a variety of purposes (Table 2, Habitual educational use of the Internet). Three items pertaining to teachers' habitual use of the Internet for preparing lessons were from the *Teacher Internet Survey* developed by Alghazo (2006). Alghazo reports a reliability coefficient of 0.84 for his entire instrument, based on a test-retest methodology. Responses were scored on a five-point scale ranging from "never" to "every day or almost every day". Cronbach's alpha for this three-item scale was 0.73. Composite scores were calculated by adding individual scores and dividing the sum by three.

To investigate the basic descriptive question of whether teachers use Great Lakes online learning materials in their classrooms, teachers reported how frequently they used specific online learning materials geared toward ESS (Table 2, Use of Earth System Science online learning materials). These survey items referred to several Great Lakes online learning materials, one ocean specific resource, and several general ESS online learning materials (Table 1). Following the method of the *LSC 2006 K-8 Questionnaire* (Horizon Research, 2000), these items asked teachers to refer to the first class of the week, if they taught multiple sections, and items were scored on a five part scale ranging from "never" to "all or almost all lessons".

To address whether learning about online learning materials predicted use of these materials, teachers responded to a set of survey questions asking whether they had learned about specific online learning materials in pre-service or in-service education (Table 2, Education about Earth System Science online learning materials). Teachers answered the questions as either "did learn" or "did not learn". A Mann-Whitney U test compared scores for usage. The Mann-Whitney U test is a non-parametric analogue to a T-test that is appropriate for scaled, in this case, a five point scale, data.

To address whether geography predicted the use of specific online learning materials, two questionnaire items asked about proximity to the ocean and Great Lakes, using a five part scale ranging from "very near" to "very far" (Table 2, Geographic Proximity). For some analyses, responses were binned into groups of "near" and "very near", "far" and "very far", and "neither near nor far". A Kruskal Wallis test (a non-parametric analogue to ANOVA) tested if teachers in five categories of proximity ("very near" to "very far") varied in the amount of use of specific online learning materials on a scale from 1 ("never) to 5 ("every class or almost every class").

To address the possibility that classroom content predicted the use of online learning materials, two questionnaire items asked how often participants taught about the ocean and Great Lakes (Table 2, Frequency of teaching about the Great Lakes and ocean). These item answers followed the *LSC 2006 K-8 Questionnaire* five part item scale described above. Responses were binned into participants who "never" used particular online learning materials and participants who reported ever using particular online learning materials. A Mann-Whitney U test compared scores for usage.

SURVEY PARTICIPANTS

Participants were a volunteer sample of K-8 teachers, recruited via invitations posted on the National Science Teachers Association (NSTA) "discussion Board" forums, NSTA listservs, and the Michigan Earth Science Teachers Association (MESTA) listserv. The use of MESTA purposely increased the sample of teachers living in proximity to the Great Lakes, so as to allow for a large enough sample to attempt quantitative, comparative analysis of the geographic data. It was assumed that participants were involved in or interested in science education, based on their familiarity with these NSTA and MESTA resources. Preliminarily, it was assumed that participants were familiar enough with the Internet that the use of online learning materials was a reasonable possibility. This assumption was verified using two portions of the survey 1) the *Internet Use for Lesson Planning* and 2) an item that asked whether teachers learned about "other" Internet resources in pre- and in-service education (i.e., those not specified in this survey).

The number of respondents was 135. Participants were not required to answer all questions, so sample size for individual items varied. Most (84%, n=134) were female. Women were 92% white, 4% Latina or Hispanic, and 3% black or African American, one woman was Asian, and one Native American or Alaska Native (n=106). All men were white except one "Latino or Hispanic" man (n=21). Participants ranged in age from 20 -24 to over 50 years (n=130). The most common age was over 50 years (50% of respondents). Only 10% were 20-34 years. All between 20-34 years of age were white (n=124). Experience range was fairly evenly distributed. The most common level of experience was 3-5 years (17%, n=124). Approximately 32% (n=132) of participants were very near (a coastal town) or near (within a short drive) to saltwater, while 39% were far (a weekend trip) or very far (more than a weekend trip) (Fig. 1). Most participants (80%, n=129) were far or very far from a Great Lake (Fig. 1).

RESULTS

This survey investigated teachers' frequency of use of online learning materials specifically produced for Great Lakes education (Table 1, Fig. 2A). However, very few of the teachers reported using any of the Great Lakes online learning materials (Fig. 2A). In comparison, only 5% of teachers reported using the BRIDGE resource, a website known to be an excellent compendium of ocean education online learning materials (Fig. 2A).

Despite the negligible use of the Great Lakes online learning materials and a comparative ocean resource (BRIDGE), teachers reported habitually using other online learning materials for teaching and planning purposes, as evidenced by the *Internet Use for Planning* composite scores. These scores ranged from 2.3 (rarely, e.g., a few times a year) to 5 (every day or almost every day) with a median score or 4.3 (often, once or twice a week). Also, the survey of less regionally specific ESS online learning materials indicated that NOAA's NWS Education Page was used by 51% of the study participants and NOAA's education page was used by 54% of the teachers (Fig. 2B). Use of other more generalized online learning materials varied, ranging from 18% of teachers using DLESE to 28% using the GLOBE Program materials. Though teachers' use of these more generalized ESS online learning materials was not heavy, it was greater than the use of the Great Lakes online learning materials and BRIDGE, an ocean resource (Fig. 2A).

Given the lack of use of Great Lakes science online learning materials, we considered whether teacher education about these online materials might predict the use of them and, thus, be a potential avenue of research into how to increase the use of these materials. A hypothesis that might explain teachers' use of Great Lakes online learning materials was that these teachers were introduced to these resources within their pre-service or in -service education. Some (14%) teachers reported learning about at least one of the Great Lakes online learning materials during their education.

Considering the online learning materials individually, between 8% (COSEE Great Lakes curriculum resources) and 1% (teach.GLIN.net) of teachers learned how to use each individual resource during pre- or in-service education (Fig. 3A). In comparison, 7% of teachers reported learning how to use the BRIDGE resource (Fig. 3A). Thus, few teachers learned how to use these Great Lakes or ocean online learning materials in their in-service or pre-service education. In contrast, most teachers reported learning how to use some online learning materials during their education (Fig. 3B). Also, 64% of teachers reported learning how to use at least one of the more generalized ESS online learning materials in their

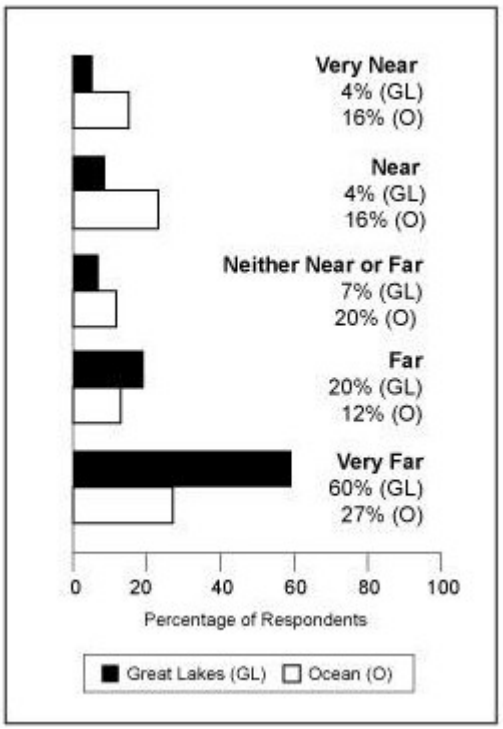

FIGURE 1. Survey participants' geographical proximity to the Great Lakes and ocean.

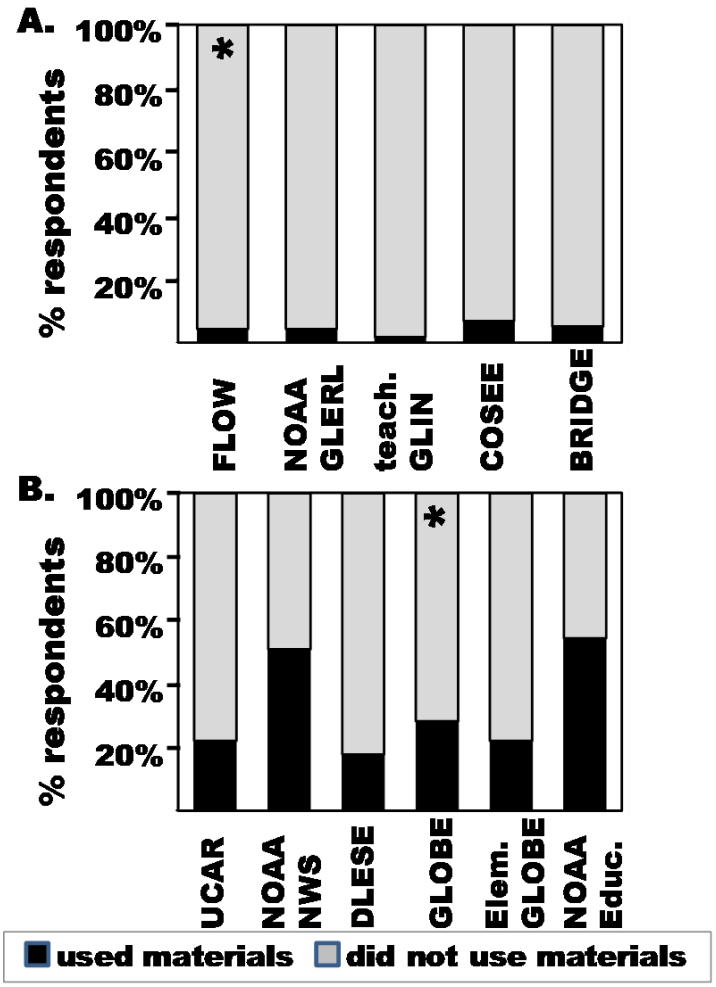

FIGURE 2. Most responding teachers did not use online learning materials developed for A) Great Lakes and ocean education and B) online learning materials developed for more general Earth System Science topics. Teachers responded to the question, "About how often do you use information or activities from each of the following during your instruction in this class?" Sample size was *n*=118 for most questionnaire items; * indicates *n*=117.

pre-service or in-service education (Fig. 3B). Thus, this lack of knowledge was not likely a result of an overall lack of education regarding the Internet.

Teachers who learned about one of these Great Lakes online learning materials reported that they used that resource more frequently than those who did not learn about the resource (Mann-Whitney-U tests, $p<0.001$ for COSEE, teach.GLIN.net, Fisheries Learning on the Web, and NOAA-GLERL). Of the 7 teachers who learned how to use BRIDGE, 5 teachers reported using the BRIDGE resource; while 2 teachers reported not using this resource. Teachers who learned about these more generalized materials in their pre-service and in-service education were more likely to use these materials while teaching (Mann-Whitney-U tests, $p<0.001$ for GLOBE, elementary GLOBE, NOAA Education Resources, NOAA NWS Education page, DLESE, and UCAR). Overall, whether teachers learned how to use online learning materials in pre- or in-service education somewhat predicted whether they were more likely to use these materials.

A second prediction was that teachers who lived in close geographic proximity to the Great Lakes would tend to make greater use of the Great Lakes online learning materials. This factor was considered to be potentially important, but beyond the control of parties interested in the use of these online learning materials. However, half of the teachers who used Great Lakes science online learning materials lived far or very far from a Great Lake, and most (76%) teachers who lived near or very near to a Great Lake reported *not* using these Great Lakes materials. Certainly, the heaviest users of teach.GLIN.net and the COSEE online learning materials tended to live very near (coastal town) to a Great Lake (teach.GLIN.net: Kruskal Wallis, $X^2=10.1$, $df=4$, $p<0.04$) and COSEE (Kruskal-Wallis test, $X^2=23.6$, $df=4$, $p<0.001$). Nonetheless, there was no substantial effect of geographic proximity on the likelihood that a teacher used these Great Lakes online learning materials. This pattern was not specific to the Great Lakes, as almost all of the teachers who lived near or very near to the ocean did not use the BRIDGE resource. Of those who did use the BRIDGE resource, 3 lived "near or very near" to saltwater, 2 lived "neither near nor far", and 1 lived "very far" from salt water.

A third prediction was that teachers were more likely to use Great Lakes online learning materials, if they taught about the Great Lakes and, consequently, had need of these specific resources. Again, this factor was considered to be largely beyond the control of those interested in the use of these online learning materials. Importantly, only a minority of the teachers taught about the Great Lakes rarely (a few times a year, 32%), sometimes (once or twice a month, 9%), or often (once or twice a week, 2%). As a result, the pool of teachers with an apparent need for the Great Lakes online learning materials was less than half (44%) of those sampled ($n=121$). The vast majority of teachers who reported teaching about the Great Lakes did not use any of the Great Lakes online learning materials. Of note, teachers who taught about the Great Lakes most frequently also made more frequent use of the NOAA-GLERL Outreach Great Lakes online learning materials (Mann-Whitney $U = 1495$, $p<0.01$) and COSEE Great Lakes Curriculum (Mann-Whitney $U = 1398$, $p<0.001$) than those who did not teach about the Great Lakes. Nonetheless, the general pattern was that the presence of Great Lakes topics within the classroom curriculum did not substantially increase the use of Great Lakes online learning materials. In comparison, almost all (95%) teachers reported teaching about the ocean. As noted above, though, only 0.5% reported using the BRIDGE resource (Fig. 2A).

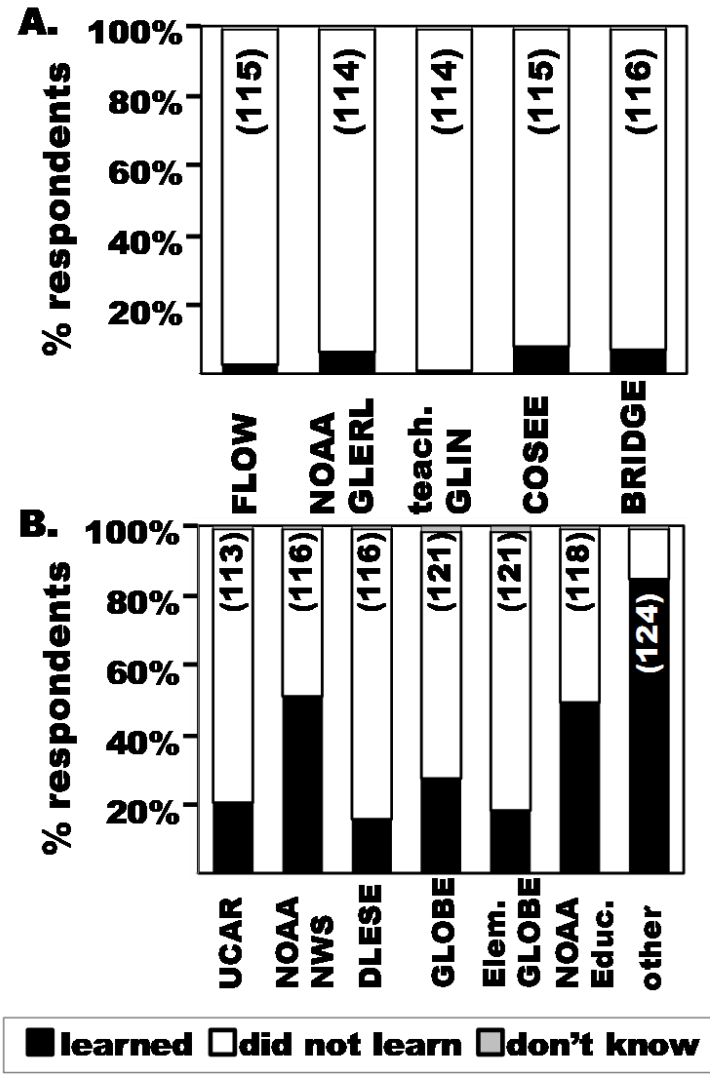

FIGURE 3. Most responding teachers did not learn about online learning materials developed for A) Great Lakes and ocean education and B) online learning materials developed for more general Earth System Science topics. Teachers of K-8 science were asked to respond to the prompt, "Please indicate whether you learned how to use the following resources during your undergraduate education, graduate education, in-service education, or workshops". Sample sizes for individual questionnaire items are indicated by numbers in parentheses. Note that <2% of respondents answered "don't know" to these items (gray shading).

DISCUSSION AND RECOMMENDATIONS

Use of Online Learning Materials

One goal of this study was to document whether and how often this sample of K-8 teachers used online learning materials that focus on Great Lakes education. Very few study participants reported using the Great Lakes online learning materials (Fig. 2A). This was not specific to the Great Lakes, as the pattern for the BRIDGE ocean resource was similar (Fig. 2A). This finding was not likely due to teachers generally not using the Internet, though the sample included a substantial sampling of teachers over 50 years of age: the survey participants reported substantial Internet use for teaching and planning purposes. Moreover, over half of the participants reported using a more generalized online learning material, the NOAA NWS Education webpage (Fig. 2B), and most of the teachers reported learning about some online learning materials during pre- or in-service education (Fig. 3B). Thus, the teachers used and learned about online learning materials, in general, but not necessarily the materials that were the focus of this study (Table 1).

Teacher Education

One clear pattern was the positive relationship between learning about online learning materials during pre-service or in-service education and using these materials in the classroom. This pattern was clear in the data regarding the Great Lakes online learning materials and was confirmed by the patterns regarding the more generalized ESS online learning materials (Elementary GLOBE, GLOBE, DLESE, NOAA NWS, UCAR). These results suggest that one promising avenue for researching how to increase the use of specific online learning resources is to consider the effect of inclusion of these resources in teacher education.

If science faculty recognize that there are aspiring teachers within their classes, they can follow the recommendation of the SERC (2008) "Preparing Teacher to Teach Earth Science" workshops, which include introducing students to ESS resources, such as the Great Lakes online learning materials described in this study (Anderson, 2007). This entails offering bibliographies and formulating class assignments to encourage students to explore specific examples of Earth System principles. Because many professors are experts in their fields, but may not be experts in the regional issues that engage children and are relevant to elementary education, one useful strategy is to leverage partnerships with state and regional agencies that have educational missions (e.g., Michigan Sea Grant, GLERL, COSEE, and Great Lakes Information Network). College and university faculty can call upon the expertise within such agencies. Collaboration between Earth Science faculty and such agencies provides a promising opportunity to offer professional development focusing on how to use specific online learning materials as tools for incorporating specific, regional contexts for basic ESS principles into the teacher-education curriculum.

Teaching how to use online learning materials of the sort in this study also requires modeling how important, but somewhat generic concepts, such as the water cycle, can be effectively communicated through the use of illustrative and important examples, such as lake-effect snow. General principles can be placed within specific contexts; for example, the Great Lakes are an example of glacial lakes and the Great lakes watershed is an important example of a major continental watershed (Table 3).

Also, workshops allow access to in-service teacher education. For example, Michigan Sea Grant has supported targeted workshops and professional development efforts through annual presentations at the Michigan Science Teachers Association meetings, through regional efforts to encourage collaboration among educators in more remote areas of Michigan, and by participating in regional COSEE Great Lakes in-person educator workshops.

Of note, many of the organizations with expertise regarding the development and use of online learning materials that focus on specific, regional contexts for ESS principles are regionally based. For example, COSEE Great Lakes is working to gain a more national presence, presenting at the NSTA National Meeting (2008), the National Marine Educators Meeting (2007), and the North American Association for Environmental Education meeting (2006). However, such efforts are relatively small scale in contrast to NOAA, which publishes the most used online learning material in this study, the NOAA NWS education webpage. At the 2008 national NSTA meeting, NOAA ran 30 sessions. Given this study's correlation between learning how to use online learning materials and use of online learning materials, it is not, then, surprising that the NOAA NWS and NOAA education materials were among those that teachers reported using the most.

On a positive note, NOAA's director of communications, Anson Franklin's statement that "The National Weather Service is probably one of the best recognized organizations in the country. Everybody uses it," (Merzer, 2007; p. A1) seems somewhat verified by this study. Unfortunately, this level of national exposure may be beyond the resources of smaller, more state and

TABLE 3. NATIONAL SCIENCE EDUCATION STANDARDS AND AAAS BENCHMARKS ALIGNED WITH ILLUSTRATIVE EXAMPLES FROM GREAT LAKES SCIENCE

Standard		Example from the Great Lakes
NSE Standard: Earth and Space Science Content Standard D	K-4th grade: Changes in the Earth and Sky	Wave erosion of bedrock on the PA shoreline of Lake Erie
	5th-8th grade: Structure of the Earth system	Clouds forming and influencing climate in the Great Lakes region
AAAS Benchmarks Online 4C: Processes that Shape the Earth	3rd-5th grade: Waves, wind, water and ice shape and reshape the earth's land surface by eroding rock and soil	Erosion of the Lake Michigan sandy shore due to waves and currents
	6th-8th grade: The earth's surface is shaped in part by the motion of water (including ice).	Formation of Great Lakes

regionally based organizations such as the Great Lakes organizations highlighted in this study. One suggestion is for interested parties to focus on educating teachers about generalized, useful means of finding online learning materials promoted by smaller organizations. For example, useful methods for finding Great Lakes online learning materials include entering the DLESE database (www.dlese.org) and search for *"Great Lakes"* + *education* or "*Great Lakes"* + *outreach*. A second method is to conduct both of the above searches in the Google search engine.

GLOBE (though not Elementary GLOBE) presents an alternative model. To become a GLOBE school the teacher must be trained to use the GLOBE protocols. Hence, GLOBE runs intensive training sessions and provides local support for teachers as they implement protocols in their classrooms (Penuel and Means, 2004). Of note, the current data suggest that this strategy may increase the fidelity of use of GLOBE online learning materials, as teachers who used GLOBE reported doing so all of the time.

Importantly, the patterns shown here are correlations, and should be interpreted as indicators to inform future research. Triangulation with other types of datasets is necessary to conclusively establish a causal relationship between teacher education about online learning materials and the use of these while in-service. Nonetheless, the results of this study indicate teacher education as a promising avenue for promoting the use of specific online learning materials.

Geography

Another factor that seemingly could influence teachers' use of online learning materials, especially those materials with a particular regional significance, is the influence of geographic locality. In this scenario, teachers geographically near to the Great Lakes would be more likely to use the Great Lakes online learning materials, and teachers near the ocean would be more likely to use the BRIDGE materials. However, this relationship was not evident in the data presented here. This indicates that geography may not be a large factor determining the use of these learning materials. This is useful background information, especially given that geography is a factor outside the influence of groups trying to influence the use of online learning resources. Nonetheless, given the overall low percentage of use of the Great Lakes and ocean online learning materials, a larger scale study is needed to confirm these patterns.

Inclusion in Realized Curriculum

A third, obvious explanation for teachers not using Great Lakes online learning materials is that teachers did not teach about the topics in these resources and, thus, had no use for the resources. Overall, this study indicated that teaching about the Great Lakes was a necessary, *but not sufficient*, condition for using the regional Great Lakes online learning materials, and the same pattern held for teaching about the ocean and the BRIDGE resource. Thus, to make possible the use of these specialized online learning materials, one strategy may be to increase the representation of the topics of these materials within the realized curriculum. However, even if these topics are within the curriculum, the online learning materials specific to these topics may still not be used. A variety of factors govern the inclusion of topics within the elementary classroom curriculum. These include local influences (such as school culture), state and district curriculum and testing policies, and teachers' personal interests and efficacies (McCutcheon, 1980; Li, 2007). Moreover, the DLESE, UCAR, GLOBE, and elementary GLOBE online learning materials support topics for almost any K-8 curriculum that includes ESS. Yet, even these more generalized online learning materials were not used by a large majority of the teachers (Fig. 2B). Thus, resource developers should note that inclusion of topics within the curriculum is unlikely to necessarily lead to a majority of teachers utilizing developed resources. Rather, active promotion of online learning materials, particularly in teacher education forums, may be advisable.

One set of efforts to increase the representation of Great Lakes and ocean in the curriculum includes advocating the inclusion of such topics in educational standards (see Ocean Literacy Network "Next Steps" http://www.coexploration.org/oceanliteracy/nextsteps.html; Schoedinger et al., 2006; Cava et al., 2005). Nonetheless, the Great Lakes represent a case of a useful and important context for many ESS concepts that is not typically mandated nor suggested for elementary education. For example, the Great Lakes are mentioned in the social studies standards in Ohio, Minnesota, Pennsylvania, and Indiana but not in the science standards (Ohio Department of Education, 2003; Minnesota Department of Education, 2004; Indiana Department of Education, 2008; Pennsylvania Code; 2008). The Great Lakes are not emphasized in the AAAS Benchmarks and are only mentioned once, as an issue of local significance, in the NSES (NRC, 1996, p. 30-31). Despite the relevancy of the Great Lakes to many aspects of life (economic, recreational, environmental) there is only minimal mandate for the inclusion of this material into the elementary science classroom, even in states with coastlines along the Great Lakes.

In contrast, the Great Lakes are mentioned in the Michigan K-8 science Grade Level Content Expectations in the ecosystems standard in both grades 4 and 6 (Michigan Department of Education - Science, 2007), and the study of the Great Lakes is included in Michigan's social studies standards document (Michigan Department of Education – Social Studies, 2007). Therefore, a study focusing on Michigan teachers may show more comprehensive use of Great Lakes online learning materials.

CONCLUSION

The results of this study present a challenge for developers of Great Lakes online learning materials who wish to ensure that their materials are incorporated into K-8 education. The Great Lakes are an example of a regional context that offers a useful forum for learning about more generalized ESS principles. It is not yet known whether the results in this study generalize to other such regional contexts, though the data regarding knowledge of and use of the BRIDGE resource indicate that such generalization is probable. The finding here suggest that the most likely

strategy for increasing the use of specific online learning materials is to educate teachers about their use in pre- and in-service education.

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