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Comprehensive Dune Study Unit Aligned with Next Generation Science Standards

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Abstract

This project presents curriculum designed for a high school unit focused on Michigan sand dunes. The centerpiece of the curriculum is a field research project that is planned, deployed, and conducted by high school students and teachers so that they can examine changes in local open sand environments. The curriculum is aligned with Next Generation Science Standards and incorporates experimental design, analytical interpretation of data, and real world application of research. This curriculum model begins with the exploration of content, including such background information as the origin of Michigan's sand dunes, processes that affect sand movement, and seasonal weather patterns in the region. The curriculum includes several modules that prepare students for field exercises along the west Michigan shoreline, including field data sheets and recognition of both dangerous and endangered
plants. The fieldwork relies on digital images to capture data at the site. Once students have acquired photos of the field area, they perform data collection and interpretation in the lab. They build as many as several hundred digital images of the site into a panorama that is hosted online, and then analyze changes revealed by comparing panoramas taken at different times during the year using on-screen measurement software and a spreadsheet for data collection and analysis. The real time data the students collect along West Michigan shorelines can be used by public and private institutions to aid in research and restorative practices in order to better understand and protect Michigan's fragile fresh water dunes and dune ecosystems.

Student installing dune pin

Introduction

The sand dunes located up and down the eastern shores of lake Michigan are a defining aspect of Michigan's coastline. Our research and implementation revolve around two main aspects. First, we are studying and measuring the movement of sand at the Kitchel Lindquist Hartger Dune Preserve (Grand Haven, MI) over time. This will be accomplished through the use of GigaPan technology that allows us to take panoramic images of the dunes. These images will later be analyzed and compared to previous pictures with the aid of pins placed throughout the dune in order to determine the movement of the sand. Second, we have collaborated with a local high school teacher to create curriculum based on the Michigan sand dunes. This has culminated in a twenty-one lesson unit plan with the addition of several supplementary activities. Each lesson focuses on a different aspect of dune ecology and history, or on related research-based activities. The ultimate goal is to create a sand dune research project that west Michigan teachers can use to teach students not only about the dunes, but also about research and analysis.

Objectives

- Study and analyze sand dune movement with the aid of GigaPan technology.
- Use this information and experience to create a unit plan based on the Michigan sand dunes for local teachers to implement in their classrooms.
- Equip teachers to involve high school students in long term, site-based research.

GigaPan and MB-Ruler

GigaPan is a camera mount system that automatically takes panorama pictures on site. Stitching software is included with the cost. The panorama is posted online (at www.gigapan.com) and can be used to measure and interpret data from anywhere with an internet connection. Students and teachers use a screen measurement tool (MB-Ruler) to measure the heights of pins set in the dunes and visible in the panoramas. Subsequent measurements can be compared with prior ones to determine the amount of sand accumulation and removal across the site.

Pros	**Cons**
•Minimal impact to the dune site •Photographs taken remotely •Good visualization of dune site •Able to better interpret the data off site •All photo data is stored and found in one location •More efficient reference	•Cost of equipment •Camera, tripod, panorama mount, GigaPan •Requires higher quality camera •Higher resolution and better lenses needed to record data from distant pins •"Stitching Issues" •Pins appear divided due to the merging of two images within the panorama

Mapping Movement of Coastal Sand Dunes on Lake Michigan using Gigapan Photo Technology Lesson Plan.

Activity Description: Students will analyze data to better answer the scientific question regarding what most strongly controls sand movement. Students will analyze the dune's response to storms, local conditions, and organismal impact. Students will observe the data collected and analyze the effects of individual variables such as dune orientation, size of open sand areas, location relative to other dunes, steepness, and shape of the dune exposure, and weather to answer the scientific question. The data that students collect will be novel and in real time, so results from this activity may be presented or shared with local dune conservationist or other academic institutions.

Estimated Lesson Time:
2 Lesson Periods
Standards:
Michigan High School:
HS-ESS1-5: Engaging in Argument from Evidence
HS-ESS1-6: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
HS-ESS2.D (HS-ESS3-6): Weather and Climate
HS-ESS2-2: Analyzing and Interpreting Data
HS-ESS2-4: Cause and Effect
HS-ESS3.C (HS-ESS3-3): Human Impacts on Earth Systems
HS-ESS3-5: Scientific Investigations Use a Variety of Methods
Michigan Middle School:
MS-ESS1-1: Patterns
MS-ESS1-2: Systems and System Models
MS-ESS1-3: Analyzing and Interpreting Data
MS-ESS1-4: Constructing Explanations and Designing Solutions

Focus Question(s):
* How can you use data to learn about an environment such as the sand dunes?
* Did the dunes change during your study? If so, how much?
* What may have caused the changes that you saw in the dune?

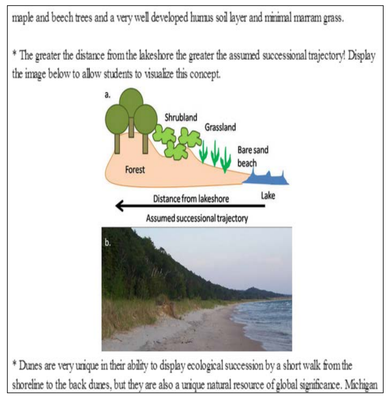
Objectives:
* Students will be able to understand and recognize the importance of data analysis aspect of the scientific method
* Students will make connections between the data that they are collecting and the impact of the dune movement

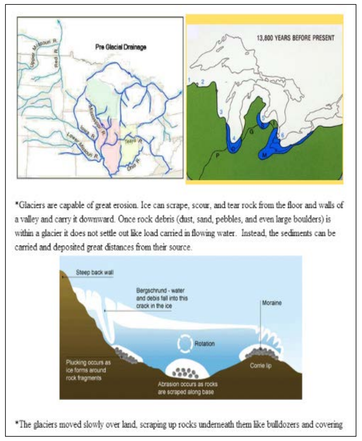
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2		June 14th 2013							June 27th 2013							
3		Pin #	Pixels in unknown length	Pixels in known length	Known length in inches	Length not measured on pin	Total pin length	Total Length (cm)	Notes:	Pin #	Pixels in unknown length	Pixels in known length	Known length in inches	Length not measured on pin	Total pin length	Total Length (cm)	Notes:
4		400	6.4007	5.6	1.5625	19.875	21.6609096			400	37.322	21.365	12.25		21.45949308		
5		401	29.203	17.802	9.1875	1.5625	13.53742206			401	25.793	22.679	12.25		13.93201861		
6		402	38.328	18.71	12.25		18.54719401			402	38.143	25.255	12.25		18.59135617		
7		403	35.598	25.339	12.25		14.79243459			403	35.598	29.695	12.25		14.68514901		
8		404	32.4	17.866	12.25		22.21538117			404	35.145	19.22	12.25		22.39990895		
9		405	30.28	25.77	12.25		14.39386884			405	33.781	17.205	12.25		24.05215054		
10		406	32.05	29.851	12.25		13.15240695			406	34.378	31.672	12.25		13.29661846		Sticks covering the contact zone with sand
11		407	33.756	29.931	12.25		13.40620093			407	33.759	30.453	12.25		13.57986898		
12		410	33.577	24.675	12.25		15.18007092			410	33.591	26.34	12.25		15.62223804		
13		411	34.3	25.5	12.25		16.47745098			411	27.518	20.611	12.25		16.3551259		
14		412	36.214	34.011	12.25		12.68329364			412	36.123	35.716	12.25		12.3895943		
15		413	19.444	35.845	12.25		12.45470777			413	19.312	14.308	9.1875		12.40068493		
16		414								414	need individual picture						
17		415	28.005	56.784	12.25		14.02351455			415	28.094	22.475	12.25		15.31263626		
18		416	28.401	31.601	12.25		12.56011677			416	28.421	22.81	9.1875		11.44752028		
19		417	30.502	34.32	12.25		12.49985431			417	30.365	29.268	12.25		12.7091448		Shadow at the bottom
20		420	34.763	30.652	12.25		13.89295152			420	35.005	29.604	12.25		14.48490913		

Sample lesson plan and data collection spreadsheet

Curriculum Development

With a total of twenty-one lesson plans and the addition of supplementary activities, each lesson focuses on a different aspect of Michigan sand dunes. The main topics of the lesson plans span angle of repose, water and wind erosion, weather, and even glacial history. There is also a section of the unit focused solely on the development of the students' own dune observation project. Our goal was to create an entire curriculum focused on all aspects of sand dunes and cater the lessons to West Michigan school teachers. The unit plan was constructed around the Next Generation Science Standards. We understood that the NGSS will be implemented in the within the next few years and we hoped that our curriculum would provide a solid foundation for implementation. Similar to goals of NGSS we attempted to add as many hands-on activities and options to our lesson plan as possible. All activities were based around the common abilities and resources that are available to most public, secondary teachers. Along with activities each lesson has a corresponding PowerPoint presentation as well as any handouts associated with the lesson.





Sample instructional materials to accompany the dune analysis project.

Testing and Results

We had a small sample of Grand Haven high school and middle school students test out the project portion of our project. The students helped to place and set up the pins, as well as measure and analyze data that they collected. The students did exceptionally well, demonstrating that students can learn to gather data from GigaPan photos and enter data into a spreadsheet with several hours of training. Equally importantly, they demonstrated that they can concentrate on the project long enough to generate useful quantities of data with good repeatability, with 6 students generating an average standard deviation of 0.16 inches in pin measurements. The response of the students may not be totally telling of the average student's behavior. The sample group was composed of students in Grand Haven's geology club, they were all interested in the subject matter, and most were at the top of their class.

Acknowledgments

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