

## Using a Classroom Observation System to Analyze Content and Inquiry in Physical Geography

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*Accepted on 11/25/11*

### Abstract

This study examined the extent to which two undergraduate physical geography teaching modules are aligned with national science teaching and learning standards and inquiry-based approaches to learning. These modules, which were implemented at a mid-sized university, were designed for both general education and pre-service elementary education students. The modules addressed the topics of differential heating and the Beaufort wind scale. Observations of teaching methodology were recorded in the physical geography classroom lecture and inquiry sessions as they were taught. These recorded observations were then analyzed and coded using a Lesson Observation System that is based on teaching and learning standards and inquiry based approaches to learning. Ratings data obtained from the System provide evidence that the two modules were taught with a high degree of consistency following the recommendations of the standards. The modules provided authentic examples to elementary and secondary education students of physical geography topics taught using an inquiry-based and standards-based approach. Pre-service teachers should benefit from models of inquiry presented in a similar manner.

**Keywords:** Science standards and inquiry, physical geography, classroom observations, pre-service teachers

### Introduction

The research literature has reported on the differences between how the majority of pre-service teacher education students experience introductory science in the college classroom and how current national teaching standards recommend that content should be presented at the K-12 levels in which most education students are preparing to teach. Willden, Crowther, Gubanich, and Cannon (2002) suggest that these college-level courses presently consist of lecture, memorization, and passive learning with little relation to students' everyday lives. They also suggest that this is an ineffective teaching method for pre-service teachers because future teachers benefit from hands-on learning that they may use as teaching methodologies in their own classrooms.

In order to overcome the passiveness of a large science lecture class, two modules in physical geography were developed and researched as the subject of this paper. The modules were designed to give students real-world problems using spatial analysis. The inquiry-based approaches in the modules complemented the classroom methods that science teachers will be expected to use in their own teaching. The classroom teaching of each module was assessed using a Lesson Observation System that was based on teaching and learning standards and inquiry-based approaches to learning.

### Inquiry in Science Learning

The role of inquiry in the learning of science has received considerable attention and funding in the United States in recent decades. Inquiry has been defined as an instructional approach in which students develop methodologies to conduct activities that do not necessarily have a pre-defined outcome (Domin, 1999). This approach requires students to actively engage with their environment in order to construct scientific meaning from observation and evidence. Inquiry has played a significant role in the drafting of the current K-12 national geography and science standards. The National Geography Standards (Geography Education Standards Project, 1994) were developed to provide benchmarks that school districts and teachers could use when developing their geography curriculum. These benchmarks indicate what American students should know and be able to do in geography at the end of

the 4th, 8th, and 12th grades. While the *Guidelines for Geographic Education: Elementary and Secondary Schools* (Joint Committee on Geographic Education, 1984) promoted the use of inquiry, the National Science Education Standards (National Research Council, 1996) proposed the most thorough application of inquiry in the elementary and secondary classrooms. The national standards for science education included a considerable focus on environmental and geographical education within the clearly defined goals for achieving science literacy for all students. The science standards claimed a new way of teaching and learning that reflected how science discovery and investigation are undertaken by scientists, emphasizing inquiry as a way of achieving knowledge and understanding about the world (National Research Council, 1996, p. xi).

Willden et al. (2002) state that specialized inquiry and standards-based courses for pre-service teachers have been designed at several universities across the United States, including the University of Maryland (O'Haver, 1997), the University of Nebraska (Friedrichsen, 2001), the University of Northern Colorado (Jones, Buckler, Cooper, & Straushein, 1997), and Pennsylvania State University (McLoughlin & Dana, 1999). Positive impacts from these courses have been observed through data obtained from a variety of sources including student journals, course evaluations, field notes, and personal interviews. Among these positive impacts were gains in both content knowledge and pedagogic content knowledge (Jones et al., 1997; McLoughlin & Dana, 1999) and gains in confidence as learners and teachers of science and in seeing the utility of science (Friedrichsen, 2001). While these studies have been completed in the more traditional science areas, such as chemistry and biology, very little research has been done in physical geography. The study that follows provides data that helps bridge this gap in the literature.

### The Geography Modules

Two different modules were presented in the lecture portion of a large general education section of an introductory geography course, Physical Geography. The second author was the instructor of the course and conducted the modules. The first author was one of two trained observers rating each module as it was being taught. More detail regarding the training of observers and the rating scale is presented in another section this paper. Each module took approximately 60 minutes to conduct.

The first module, "Campus Thermal," focused on the concepts of albedo and differential heating. Students formed small groups (3-5 students) and each



group was given a worksheet to complete for the module. They were then shown the "front page" of the module as it was designed for Internet display which included the following objectives:

- a. Understand the albedo-temperature relationship of different surfaces and aspects of those surfaces.
- b. Recognize relevant ways albedo and differential heating are important.
- c. Recognize that sometimes data can be deceiving and nature may represent variability around the expected observations.

The next "page" of the module showed a map of campus and provided pertinent information such as the data collection points and the day and weather conditions for when those data were obtained. From here the instructor preceded by showing students nine data collection locations (three grassy surfaces, three bare surfaces (asphalt, concrete, and granite), a water surface, an aluminum surface, and the atmosphere). Groups were asked to examine the images along with the information provided for each location such as slope aspect or slope composition and answer the questions provided on the worksheet related to these images. For instance, groups were asked to determine which four locations had the highest albedo and explain why that was the case. Another question asked groups to determine which four locations would reach their highest temperature of the day the earliest time of day and explain their answers. The instructor walked around the lecture hall while students were discussing their answers to the questions. The class was called to attention and individual groups were asked to give their responses. A class-wide discussion focusing on these answers ensued. The instructor explored the reasoning processes employed by groups of students that led to their responses. At various times comments such as "I am interested in your reasoning [behind your answer]" and "I don't know the answer because I didn't measure it, but we can make reasonable deductions" were made by the instructor to show students that sometimes a specific answer is not the goal of the activity.

The second module, "Blown Away," focused on wind and the Beaufort Wind Scale. It was conducted in a manner similar to the prior activity. Students formed small groups (3-5 students) and again were given a worksheet for the module. Groups were also provided a handout of the Beaufort Wind Scale which provided the Beaufort number, wind speeds corresponding with each Beaufort number, and effects observed on sea and land from these various wind speeds.

The module began with the following objectives:

- a. Recognize general wind speed using visual environmental evidence.
- b. Interpret the Beaufort Wind Scale.
- c. Recognize relevant ways that wind affects people or is of use to people.

A series of nine video clips that illustrated the effects of different wind speeds on water bodies, flags, and trees were shown on a large screen at the front of the lecture hall. Groups were asked to identify the Beaufort Wind Scale number represented by each video and record it on their worksheet. The instructor also asked groups to generate responses to several questions related to sailing such as "When sailing, is it possible to sail against the wind?" "How does [the sailboat] move upwind?" and "With a downwind sailing rig, much like a spinnaker on larger sailboats, what is the physically fastest speed the boat can move?" (a numerical answer for this question was not necessary, but one that reflected the information necessary to answer the question was expected). Finally, groups were asked to discuss and generate answers for two questions dealing with air pollution. These questions were: "In 2004, Kalamazoo County was listed as "non-attaining" in terms of air pollution regulatory standards set by the Environmental Protection Agency (EPA) and is required to develop a plan to address this problem. What is fundamentally different about this task for Kalamazoo County?" and air pollution from "Oil wells burning in Kuwait or the eruption of Mt. Pinatubo (volcano) in the Philippines? Do these types of events in other parts of the world affect Kalamazoo? Explain your answer." As with the previous module, the instructor walked around the room clarifying words or questions for groups and a large group discussion with the instructor took place. The instructor was primarily interested in students' reasoning processes, even though the questions in this module had concrete answers.

#### Lesson Observation System

The study employed the Science and Mathematics Program Improvement (SAMPI) Lesson Observation System. This observation system is a prescribed protocol for obtaining data based on observations gained during content-based lessons. The system is designed for K-12 classrooms, but can be applied to college classrooms, as it was for this study. It is "based on Michigan and

national teaching and learning standards in core subject areas with an orientation toward inquiry and investigative approaches to learning" (SAMPI, 2003b, p. 1).

The system guides trained observers through four steps: (1) watch and take notes through the lesson; (2) complete a debriefing form; (3) compile and analyze data collected; and (4) report on findings of analysis to teachers who were observed. It makes use of several observational indicators formulated to fit three main components of the lesson (implementation, content, and classroom culture) and those are rated on a 7-point scale with 7 being the highest score possible. Following the indicators for each of the three components of the lesson, an "overall" rating for that component is assigned using the 7-point scale. Finally, a summary rating for the entire lesson is assigned using the 7-point scale. This rating is determined from the overall ratings for the three components of the lesson and from Yes/No answers given for several questions related to a fourth component, planning/organization of the lesson. This summary rating is useful for obtaining an overall evaluation of the processes and effectiveness of the lesson presented (SAMPI, 2003a). Higher summary ratings indicate a greater consistency with national standards and with inquiry and investigative approaches toward teaching and learning.

The reliability and validity of the Lesson Observation System has been established. Cronbach's alpha was applied to determine the consistency of the system. Based on 120 sets of scores, the results were 0.85 for the implementation section, 0.80 for the content section, 0.64 for the classroom culture section, and 0.88 for the entire system (SAMPI, 2003c). The validity was established during the initial development of the system. An advisory group consisting of science educators completed a validation review based on their experience and knowledge. National and state teaching and learning standards and other pertinent documents were reviewed for science instruction relative to the observational system. This was done to identify the "appropriate criteria for assessing . . . science lessons" (SAMPI, 2003c, p. 4). A final set of criteria was established following science educators' reviews, pilot observers' ratings, and suggestions provided after use by observers.

In order to correctly implement the Lesson Observation System, observers are required to complete a training workshop. The workshop presents videos of actual classroom lessons for observers to practice the skills necessary for reliable observations and ratings. The observers for this study were trained in the proper implementation of the system.

### Implementation of the Lesson Observation System

Each module took approximately one hour each to complete in two class sessions. Both observers attended the classroom sessions and made handwritten notes at one-minute intervals. The two observers did not interact with or consult one another while making notes (for an example of several minutes of transcribed notes for the "Blown Away" module, see Figure 1). Each observer's ratings, as well as a brief description of the supporting evidence for those ratings, were recorded on a "Lesson Observation Debriefing Form" (for an example a portion of the form for the "Blown Away" module, see Figure 2). Observers did not consult one another when completing the debriefing form. These ratings were analyzed to determine how well the two module lessons were aligned with teaching standards and with an inquiry-based approach to learning.

9:32 a.m. – This class is in a large lecture hall almost completely filled with students. I only see 1 or 2 empty seats. The instructor says, "Good morning, everybody! Does anyone have any questions?" There is no response so the question is asked again, "Are there any questions as to what we've done so far?"
9:33 a.m. – Instructor tells the class that they are going to go back to the previous chapter and do an in-class assignment on the Beaufort wind scale. It is a scale to classify wind speed based on strength, she tells them. She tells them to get into groups of three.
9:34 a.m. – Students move around and get into groups. Instructor walks around and makes sure every group has three members.
9:35 a.m. – Instructor continues to walk around to make sure every group has 3 members. She walks around the whole class.
9:36 a.m. – Instructor is continuing her walk around the class. Finally she says, "I think we're good now! The first sheet you are going to get is the Beaufort sheet. Use it to answer the first questions on the worksheet, which is the second handout you are going to get." There are two teaching assistants passing out the first handout (the Beaufort Wind Scale sheet).
9:37 a.m. – Hand-outs are still being given out by the TAs.
9:38 a.m. – Instructor comes around with the second sheet (the worksheet with the questions). Students are engaged in much chattering. Instructor says, "Does everyone have the Beaufort Wind Sheet and the worksheet?"
9:39 a.m. – Instructor says, "Make sure that one worksheet per group has the names of everyone in your group! You are going to be handing it in. Everybody ready? We are going to look at a series of video clips. We are going to get an idea of how fast the wind is going in each of these video clips."
9:40 a.m. – First video (projected on the screen at the front of the class) – a video of Lake Michigan from the shore of South Haven. Instructor says, "Compare what you see with the descriptions on the Beaufort wind sheet. What is the Beaufort number? How fast is the wind blowing? Write it on your worksheet."
9:41 a.m. – Students discuss. Instructor says, "Do you need to see it again?" Instructor shows the video again after many students say, "Yes."
9:42 a.m. – Instructor says, "Here's the next video." Second video – the Gulf of Mexico off the coast of Mississippi. Students discuss. Instructor asks, "Anybody need to see it again?" Instructor shows it a second time. Instructor points out that there are some islands in the video that are not there anymore. "They were wiped out by Hurricane Katrina."
9:43 a.m. – Third video – Lake Austin in Portage. "This is the last of the water ones," Instructor says. Students discuss and make their guesses about the Beaufort number.
9:44 a.m. – Instructor says, "Let's look at some flags!" Fourth video – flag poles on campus. Students discuss in their groups. They are making a guess as to how fast the wind is blowing based on the waving of the flags.

Figure 1. Example of transcribed notes taken during the "Blown Away" module.



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*This form is only one component of a comprehensive lesson observation system.*

### CLASSROOM CULTURE IN WHICH THE LESSON WAS CONDUCTED

1. Active participation of all students was encouraged and valued. 7  
 (1 = Participation not encouraged/ not valued, 7 = Participation strongly encouraged/ valued)  
 Supporting evidence for rating: The instructor walked around to be sure everyone was participating during the group work. She threatened to take away any cell phones that were in use. She called on students randomly to answer questions.
2. The teacher showed respect for and valued students' ideas, questions, and/or contributions to the lesson. 7  
 (1 = Limited respect/value, 7 = Great respect/value)  
 Supporting evidence for rating: She was respectful and listened to questions. That doesn't mean she always answered them, but she referred them to their notes when possible, which to me is respectful of them as it assumes they are good students. She asked for questions frequently, and designed the latter part of the lesson to ensure that they understood how to do the calculations.
3. Students showed respect for and valued each other's ideas, questions, and/or contributions to the lesson. 7  
 (1 = Limited respect/value, 7 = Great respect/value)  
 Supporting evidence for rating: The discussion I heard in the groups was respectful. They were arguing, but listening to each other as well. In whole-group discussion, they listened to each other and were attentive when others were speaking.
4. The classroom climate for the lesson encouraged students to generate ideas, questions, conjectures, and/or propositions. 7  
 (1 = Climate discouraged students, 7 = Climate encouraged students)  
 Supporting evidence for rating: The questions on the worksheet were designed to do this, as was the discussion of those questions afterward. Also, the instructor pointed out the subjective nature of the BWS and that answers to this would vary within a narrow range.
5. Student-student interactions reflected collaborative working relationships. 7  
 (1 = Limited collaborative relationships, 7 = Strong collaborative relationships)  
 Supporting evidence for rating: As far as I could see, everyone was included in the group discussions, and there was definitely a lot of arguing and making points within the groups, but all with the idea of arriving at answers that would make sense of the questions.

Figure 2. A portion of the debriefing form of one observer from the "Blown Away" module.

## Results and Discussion

### Lesson Observations

Ratings based on the Lesson Observation System (indicator, summary, and overall) suggest the degree of alignment between instruction, the national science standards, and with inquiry-based approaches to learning. Ratings of 1 and 2 were an indication of poor alignment. Ratings of 3, 4, and 5 indicated some alignment with notable areas for improvement. Ratings of 6 and 7 indicated high alignment. Results of the observers' ratings indicated that both modules were highly aligned with science standards and with inquiry-based approaches, as the overall lesson rating was 6 on a 7-point scale for both modules. This degree of alignment was also illustrated by the overall ratings for each set of indicators (implementation, content, and classroom culture). The areas that needed improvement appeared when individual indicators were examined in detail (Table 1).

Table 1.  
 Observer ratings for the "Campus Thermal" module.

INDICATOR	OBSERVER 1	OBSERVER 2
Arrangement of the room	4	4
<b>Planning/Organization Items</b>		
Pre-packaged program?	No	No
Adequacy of classroom resources	6	7
Lesson organized to provide teacher-student interactions?	Yes	Yes
Lesson organized to provide student-student interactions?	Yes	Yes
Investigative tasks essential elements of the lesson?	Yes	Yes
Lesson addresses different learning styles/levels?	Yes	Yes
Lesson incorporated technology?	Yes	Yes
<b>Implementation Items</b>		
Instructor confidence	7	7
Teacher-student interaction	6	7
Classroom management	6	6
Pace of the lesson	6	7
Student-student interaction	6	6
Reflection on the lesson	5	6
Wrap-up of the lesson	5	7
<b>Overall implementation rating</b>	6	6
<b>Content Items</b>		
Importance of lesson content	7	7
Intellectual engagement of students	6	6
Portrayal of subject matter	6	7
Instructor competence	7	7
Application to the real-world	7	7
Use of abstraction	4	7
<b>Overall content rating</b>	6	7
<b>Culture Items</b>		
Active participation of students encouraged	6	6
Teacher's respect for students' ideas	6	7
Students' respect for other students' ideas	7	6
Students encouraged to generate ideas	7	7
Student-student collaborative relationships	7	6
Teacher-student collaborative relationships	7	7
<b>Overall culture rating</b>	7	6

The "arrangement of the room" received a lower rating (4 or 5) for both modules based on the reports of both observers. The room was outfitted with long tables bolted to the floor and chairs attached to the table supports, this provided a setting that was not conducive to group work. Some students knelt on the floor in order to interact with their group. Because this is a large enrollment course, the lecture portion of the course was always scheduled in an auditorium. Conducting the modules in the laboratory setting where the chairs were moveable or, having smaller groups of 2-3 students could alleviate this problem. In smaller rooms and laboratories, the students could discuss the discussion questions presented by the modules even when sitting side-by-side in anchored chairs.

For the "Campus Thermal" module, "reflection on the lesson" was another lower rated indicator. The observer felt that the instructor could have set aside more time for students to reflect on the meaning of the lesson and on how albedo affects their everyday lives. The indicator "wrap-up of the lesson" had the most variability between observers. While one observer felt that the lesson had an adequate wrap-up, the other observer felt that more could have been done such as asking students what they learned from the module.

The "Blown Away" module (Table 2) and the "Campus Thermal" module had the same classroom arrangement issues since they were conducted in the same classroom. Unlike the prior module, "Campus Thermal," this module received the lowest rating on the "teacher-student interaction" indicator. This was not surprising considering that students were asked to interpret the Beaufort Wind Scale value from observing video clips. Students applied the principles of the effects of wind on various objects, but were not certain of the specific wind speeds.

When individual indicators were examined, the "Blown Away" module somewhat better aligned with the content standards and inquiry approach than the "Campus Thermal" module. But what did students think of them?

#### Student Responses to Modules

The researchers were most interested in determining how well each module aligned with national teaching standards and inquiry-based learning approaches. They were also curious to know what students thought of these modules. Students were asked to answer the following questions at the end of each module:

Table 2.  
Observer ratings for the "Blown Away" module.

INDICATOR	OBSERVER 1	OBSERVER 2
Arrangement of the room	4	5
<b>Planning/Organization Items</b>		
Pre-packaged program?	No	No
Adequacy of classroom resources	7	7
Lesson organized to provide teacher-student interactions?	Yes	Yes
Lesson organized to provide student-student interactions?	Yes	Yes
Investigative tasks essential elements of the lesson?	Yes	Yes
Lesson addresses different learning styles/levels?	Yes	Yes
Lesson incorporated technology?	Yes	Yes
<b>Implementation Items</b>		
Instructor confidence	7	7
Teacher-student interaction	5	5
Classroom management	6	7
Pace of the lesson	6	7
Student-student interaction	6	7
Reflection on the lesson	7	6
Wrap-up of the lesson	7	6
Overall implementation rating	6	6
<b>Content Items</b>		
Importance of lesson content	7	7
Intellectual engagement of students	6	7
Portrayal of subject matter	6	7
Instructor competence	7	7
Application to the real-world	6	7
Use of abstraction	6	7
Overall content rating	6	7
<b>Culture Items</b>		
Active participation of students encouraged	7	7
Teacher's respect for students' ideas	6	7
Students' respect for other students' ideas	7	7
Students encouraged to generate ideas	7	7
Student-student collaborative relationships	7	7
Teacher-student collaborative relationships	7	7
Overall culture rating	7	7

1. What did you like about the module and why?
2. What did you find the most frustrating about the module and why?
3. What would you change about the module?

The features that students liked about each module were similar; they liked the interactive, hands-on engagement. They also like practical applications of geographical science to real-world examples. Students mentioned that working in small groups was an advantage because they could discuss answers. Small group work also helped those who had a different learning style from the traditional expository (lecture) presentation of content.



The frustrations with each module were more varied. Students expressed the greatest frustration over not having one correct answer for the albedo questions in the "Campus Thermal" module. Another problem for students was that the data table presented on the screen was too small to effectively read from the back of the room. A third issue was that some terms and definitions were difficult to understand (e.g., "emissivity"). Both were cited by students in their suggested changes to the module. They recommended that making the data table larger for projection and/or providing it as a handout would eliminate this frustration. Students also mentioned that rewording the definitions in the module may make them easier to understand.

Students cited frustration with the "Blown Away" module, including the size and quality of the videos, the subjective nature of the Beaufort Wind Scale, and the application questions regarding sailing and sailboats, and the local region (Kalamazoo County). They suggested taking new videos with better, more modern equipment to remedy their first frustration. In addition, students requested more information on the Beaufort Wind Scale and on sailboats, as well as a simple definition of "non-attaining." Many students asked the instructor what this word meant during their small group discussions.

While students expressed certain frustrations with each of the modules, they did indicate that they liked the format. The students also felt they learned the concepts a little better than they would have had they just been presented through a traditional lecture format.

### Conclusions

The objective of this study was to determine how well two physical geography teaching modules were aligned with national science teaching and learning standards and inquiry-based approaches to learning. Evaluative data were obtained through the use of the Lesson Observation System. The data collected by the observers suggested that the two modules were taught with a high degree of alignment with both the national science standards and inquiry-based approaches to learning. The modules were judged to provide an authentic example to elementary and secondary education students of the methods for teaching physical geography topics within the context of the national science standards. While these modules were not designed for pre-service teachers, they did provide the students with examples of inquiry-based learning approaches to classroom teaching. The modules addressed the need for higher education science instruction to be cognizant of the

post teacher certification instruction expected of K - 12 science teachers (DeTure, Gregory, & Ramsey, 1990; McLoughlin & Dana, 1999; Mechling, Stedman, & Donnellan, 1982; NSF, 1996).

The room arrangement was the most important inhibitor of using inquiry processes in the larger lecture section of physical geography. If the modules were presented in a smaller classroom, such as a teaching laboratory, then the observed effects of the instruction may improve because discussion opportunities among smaller groups of students would be more practical. Another way to improve the overall quality of each module would be to add "discussion" items in order to encourage both small and large group discussion. The instructor could ask students to explain how the main concepts of the module were related to past concepts and topics presented in physical geography, and how those concepts and topics could be combined with the topics of the modules and used in their day-to-day experiences both in and outside of the classroom. Students could also be asked how these concepts relate to other subjects and to their chosen career paths.

There were several subjective observations made by the instructor, the second author of this paper. It was observed that students understood the concepts from the modules more thoroughly. Student attentiveness and class participation were higher during the module presentations than during prior and subsequent lectures.

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