Asteroids

Asteroids oh so scary
Some are big and some are glary
When you see one in the night
It could give you quite a fright

Flying across the sky so fast
It's quite a surprise they really last
They killed out dinosaurs in the past
It must have been quite a blast

They've been known to fly everywhere
Day and night here and there
Some of them in the asteroid belt
If one hit Antarctica it could melt

They could hit a truck and kill a duck
And kill a bull about to buck
Riding one would be quite fun
You'd be going faster than a bullet from a gun

Camden McCosker, 11 years
Australia

Poem

Neutron, photon, electron and ion
Science only turns my brain on.

Bugs and animals, plants and trees
Give me some biology please.

Explosion, reaction, chemicals and test tube
Chemistry loves me, chemistry loves you.

Einstein, Friction, Motion, Lotion
Physics gives me a sweet emotion.

Science, Science, it's so good for me
Won't you come and experiment with me?

Brock Didenko, 15 years
Hong Kong

A Writing Template for Probing Students' Geological Sense of Place

Renee M. Clary
Mississippi State University, MS, USA
rclary@geosci.msstate.edu

James H. Wandersee
Louisiana State University, LA, USA
jwander@lsu.edu

Abstract

Because many incoming geoscience students did not acknowledge their previous personal encounters with the earth's geological processes or products, we developed the Geological Sense of Place (GSP) template as a convenient way to assess students' earth science backgrounds through short answer, mini-essay, and induced associative responses. The GSP was administered in introductory earth science courses for elementary education majors (n = 42, n = 56), and in a non-major introductory physical geology course (n = 148) at a large research university in Louisiana (US). Student opinions about the GSP were gathered as part of anonymous electronic surveys at the end of the semester (earth science courses, n = 45, n = 56; physical geology course, n = 134). Students reported that the GSP integrated their past life experiences with geology, and initiated geological thinking. Our research indicates that the GSP provides teachers with a standard method to ascertain students' personal geological knowledge and experiences before instruction begins, and to incorporate these experiences into the classroom. Teachers can determine the impact of instruction on knowledge integration by comparing initial GSP student responses with responses in the post-instruction section of the GSP.

Because very few states in the United States of America mandate geoscience or earth science courses in the school science curriculum, the majority of students do not systematically encounter formal earth science courses in their secondary education. Although North Carolina mandates earth and environmental science as one of three high school science courses required for graduation, it is one of the few US states to do so. Some students may be introduced to the geosciences in middle school as part of an integrated science curriculum (such as Louisiana's seventh- and eighth-grade middle school science courses), and some high schools may offer earth science or geology as elective courses (such as in Texas high schools). This sporadic and inconsistent geological instruction means that many US high school teachers and college instructors encounter students who have had little formal geoscience instruction for several years. Some students will also equate *experience* in the earth sciences with *instruction*, and thus believe that they have had very little interaction with geology and geological products throughout their lives. After all, most of the students have not witnessed earthquakes and volcanoes, considered by many of our incoming, non-science majors to be the typical geological processes.

We developed the Geological Sense of Place (GSP) writing template to encourage secondary and postsecondary students to reflect upon their previous interactions with the earth, and to stimulate students to demonstrate to themselves that, as citizens of our planet, they have encountered and engaged the earth in numerous aspects other than during standardized instruction. Our memory-probing and open-ended questions serve as a guide for student self-reflection and diagnostic assessment. Through the GSP, students can access their prior geoscience experiences before instruction begins. Equally as important, the GSP allowed us to build, during instruction, upon what students already knew.

Theoretical Rationale for the GSP

When our students enter the earth science or geology classroom, their previous, dissimilar geological instruction is compounded by the fact that they are not carbon copies of each other. However, even when geoscience educators acknowledge that each learner is different, and that each learner brings different knowledge and experiences into the classroom, the typical blueprint for an introductory geoscience course often allows little deviation from the standard curriculum. The variations among students' experiences and knowledge are far from insignificant. Ausubel's (1978) famous dictum can be paraphrased: "The most important thing that the learner brings to class is what the learner already knows; find out what that knowledge is and teach accordingly." Furthermore, the human constructivist learning theory advocates that new knowledge encountered by students during instruction be linked with the student's prior knowledge and/or experiences (Mintzes, Wandersee, & Novak, 1998, 2000). The administration of the GSP at the beginning of a class provides an easy and efficient way for teachers to ascertain prior student knowledge about, and individual experiences with, the earth. It also provides the impetus for students to reflect upon their previous personal encounters with earth processes. Through the GSP, an instructor facilitates metacognition by encouraging students to become self-monitors of their geological knowledge and feelings toward the earth and its products. This also forms the base upon which the teacher can scaffold instruction. Therefore, the GSP allows the teacher to ascertain each student's prior geological experience, and potentially custom-fit the curriculum to the varying degrees and types of earth interaction current students have had.

Probing Students' Previous Geoscience Experiences

The Geological Sense of Place template (Figure 1) is used to uncover the past experiences of each learner when she or he enters the classroom. This writing template is designed to elicit and probe

Geological Sense of Place Writing Template

Name: _____

The goal of this learning tool is to help you recall, and connect, the experiences you had with geological products, landforms, and processes as a youth with the concepts you are learning about physical geology this semester.

PART I: Write short answers to each of the 17 "memory probes" below.

1. Which geological product was an important part of "playtime" in your yard?
2. What part of the earth interested you the most as a child?

3. Was there a particular rock or earth-related item that you enjoyed collecting during your childhood?
4. Did you have a particular chore or job as a youth that involved rocks or minerals?

5. Was there a favorite rock or landform you used to sit on or climb in your neighborhood?
6. As a youth, what was your favorite geological process to read about, view on television, or experience?

7. Did any of your childhood crafts involve making things from rocks or geological products?
8. Did any particular kind of rock have a texture you enjoyed touching as a youth?

9. What was the most unusual rock, landform, or geological process you encountered as a child?
10. Did you have your own rock or fossil collection? If so, which types did you have?

11. What geological formation or product was your town or geographic area most famous for?
12. Was there any particular geological object or landform you avoided, or were afraid of as a child?

13. What exotic geologic location made a big impression on you as a child?
14. Were there any sounds associated with geological processes or events you can remember from your childhood?

15. Did you have a person in your youth who was your geology mentor, and what did you learn from her/him about identifying or understanding rocks, fossils, or earth processes?
16. What was your favorite gemstone as a child, and why?

17. When you hear the word *rock*, which color do you associate with the word?

PART II: Complete two mini-essays using memories that you've "tapped into" during PART ONE. Choose any of these "take-off sentences" to begin each essay you write. Use the two attached blank pages for the actual essay writing.

A. It was one of the very best days of my childhood, and it involved the rock/mineral/landform called . . . .

B. The geological process I learned the most about from practical experiences in my childhood was . . . .

C. I had been warned about the . . . (geological object, landform, or process), but I didn't . . . .

D. When I think of my grandmother/grandmother/father/mother (circle one), the geological object, event, or landform I associate most with that person is the . . . . My memories revolve around . . . .

E. From my youth, I remember this geological object/process/landform was featured in the story . . . , most prominently--of all the children's books that I read--because . . . .

PART III: What connections do you NOW see between your own memories of your geological sense of place and three selected physical geology concepts that you are learning about in this geology course?

Geology concept A: _____ Connection: . . . .

Geology concept B: _____ Connection: . . . .

Geology concept C: _____ Connection: . . . .

Figure 1. The Geological Sense of Place (GSP) writing template designed to probe students' past interactions, associations, and knowledge of the earth, its processes, and products.

students' prior interactions, associations, and knowledge about the earth and earth products that they have encountered in their daily lives, from childhood up to the present.

Each student brings a unique geological sense of place to the classroom. A student's GSP is defined as an affective and intellectual state, as determined by our GSP writing template. Students reflect upon the questions in the GSP, which are designed to probe the particular geological products, processes, and experiences that made an impression on them during their lives to date. Once accessed through writing, this background information is useful to both the instructor and the student as a foundation for teaching and learning about the geosciences. Having a standard writing template also allows teachers in different schools to use a common instrument for probing and comparing the geological backgrounds of their students across classes.

Our GSP writing template comprises 17 initial "memory probes," a choice of five mini-essay prompts, and three geological associations. The template questions and probes are based upon the existing science education research literature, as well as the geography education and environmental education literature, where the general concept of *sense of place* is already familiar (Matthews, 1992; Nabhan & Trimble, 1994; Schneider, 2000). Anne Whiston Spirn (1998) stated that the landscape of our youth has been "read" with our senses, and we are, therefore, "imprinted" with it. Spirn further declared "a person literate in landscape sees significance where an illiterate person notes nothing" (p. 22). Therefore, the purpose of the GSP writing template is to help students recall, notice, see significance, and reflect upon the geology--or landscape--surrounding them. Since we believe that a landscape has a biological component as well as a geological one, we have also designed and tested a parallel writing instrument, the Botanical Sense of Place (BSP) writing template for use in introductory botany courses (Wandersee, Clary, & Guzman, in press).

Administration of the Geological Sense of Place

Parts I and II of the Geological Sense of Place writing template are administered at the beginning of a course in geology and/or earth science. Students often enter the earth science or geology classroom believing they have had few or no geological interactions throughout their lives, thus making the course appear irrelevant. However, students have lived with the earth and its processes, even if they have not consciously reflected upon their relationship with their physical environment.

Within the first week of class, the teacher should assign Parts I and II. The teacher should emphasize that, unless a student requests that his or her stories and responses not be shared, students' stories and summaries may be incorporated into the class during the semester, but that students' names will not be revealed--unless a student elects to reveal his or her identity. At the end of instruction, the teacher should assign Part III to the students, either as a writing assignment within class, or as an electronic assignment outside of class. The GSP was originally designed as a printed, in-class handout. However, in a pilot test with a large introductory geology class primarily comprised of recent high school graduates, the GSP template was modified into a web-based electronic survey to be completed by students outside of class.

Pilot Studies of the GSP

Methods. We conducted pilot studies of the GSP at a large research university in Louisiana, USA, where the majority of students are commuting, local residents. Two sections of the Earth Science course (Pilot A, $n = 42$; Pilot B, $n = 56$) and one section of the introductory Geology and Man course (Pilot C, $n = 148$) were administered the GSP at the beginning of the semester. (For all

three pilot studies, *n* here represents the number of students who successfully completed all three parts of the GSP. Data were not used from those students who completed Parts I and II of the GSP, but who subsequently dropped the course and/or were not present for Part III of the GSP.) The first author was the instructor for all three classes. The Earth Science course consists of education majors who are required to take the class for their teaching degree and certification. Since this may be the only geoscience course that students take at the university, the projects that are assigned--such as the GSP--are chosen so that they can also be included in these future teachers' own classes after graduation. The Earth Science course (maximum lecture capacity 60 persons) consists of 2 lecture hours and 2 laboratory hours per week, with the students subdivided into three sections for laboratory work (maximum capacity 20). Students are primarily exposed to physical geology content, with minor introductions to historical geology, oceanography, meteorology, and astronomy. The introductory Geology and Man course is comprised of non-science majors, who are mainly recent high school graduates. This course is taught in a large lecture format, with 3 lecture hours per week (maximum capacity 200). Since the geology content of the two courses is similar, students may not receive credit for taking both courses.

Students were instructed to access the GSP (Parts I and II) electronically on the course website. They were informed that the goal of this exercise was to help them recall their personal experiences with the earth so that they could connect these past interactions with the material that would be introduced in the course. The instructor asked students to skim the chapter titles of their textbooks (Lutgens & Tarbuck, 2002; Monroe & Wicander, 2001) in order to become familiar with the topics that would be covered during the semester. Directions for retrieving the GSP survey were posted in class and on the *Announcements* page of the course website. The instructor also demonstrated in class how to locate and answer the GSP. The students were encouraged to access the GSP within 2 days, and to answer the questions themselves, without assistance from other students. No student in any of the three pilot studies requested that his or her answers not be utilized in class. The GSP was counted as a quiz score, with full points (10/10) being awarded if the student completed the entire activity.

The instructor compiled the responses and provided the class with feedback, at the end of the week, in the form of a general summary. Throughout the semester, the instructor integrated, where appropriate, some of the interesting stories that were submitted for Part II of the GSP. In all but one case, the students very willingly identified their stories.

At the end of instruction, students received Part III of the GSP and were asked to make connections to, and associations with, the concepts plate tectonics, geological agents, and rock cycle. Students were allowed to see and reflect upon their previous responses to Parts I and II as they completed Part III. Finally, as part of anonymous, end-of-semester surveys, students were queried about their impressions of the GSP (Pilot A, $n = 45$; Pilot B, $n = 56$; Pilot C, $n = 134$). Data was collected using the questions "what is your opinion of the Geological Sense of Place Survey?" and "did this survey help you to connect with the Earth and/or geology in any way at the beginning of the course?" as well as spontaneous responses to "what was the best thing you liked about this course?" Because the anonymity of these surveys made it impossible to determine which responses could be attributed to students who fully participated in all three parts of the GSP, all responses from the end-of-semester surveys were used in our analysis. (In Pilot A, not all students were present during the completion of Part III of the GSP, and their data were not utilized in this study. However, since we were unable to determine the identity of the responses in the end-of-semester surveys, we did utilize all 45 student responses.)

At the last class meeting, students were asked whether their data from the GSP and surveys could be later used anonymously by the researchers in science education studies. They were told that denying permission would not affect their grade in the course, and a collection box for the permission forms was set up at the front of the classroom, with students turning in the signed forms face down. All students agreed, and signed written release forms to this effect.

Data and results. We determined through informal interactions that students in all our pilot studies had fairly similar backgrounds, indicative of the university's local student population which shared a common geological landscape and comparable earth experiences. For example, more students identified rocks as important during play time (Pilots A = 40.5%; B = 50.0%; C = 40.5%), with dirt and mud also scoring high marks (A = 40.5%; B = 41.1%; C = 27.0%). Only a minority of students had not made collections of earth materials during their youth (28.6%, 14.3%, and 22.6%, respectively), and those students who did have collections overwhelmingly reported they had rock collections (35.7%, 42.9%, and 39.7%, respectively).

Surprisingly, many students could not identify a favorite rock or landform from their youth (42.9%, 26.8%, and 25.7%, respectively). Typical of the Gulf Coast South, students who could identify a favorite landform chose local features such as hills, mounds, or levees more often (26.2%, 32.1%, and 22.3% respectively). We were able to build upon many students' previous knowledge of levees, and discuss potential downfalls of channeling a river system. Interestingly, when students were asked to name their favorite process, they chose something that they had never personally encountered! All pilot groups chose volcanoes as their number one process (40.5%, 37.5%, and 43.2% respectively). Therefore, we modified instruction to include more discussion on volcanic processes, and we incorporated several video clips.

The smoothness of crystal faces made the largest tactile impression among students in all three pilot courses (57.1%, 60.7%, and 47.3% respectively). Auditory associations, however, were difficult for many students (26.2%, 33.9%, 48.6%). Those students who could recall a sound associated with their youth answered "running water" (19.1%, 12.5%, 18.2%) or "ocean waves" (14.3%, 16.1%, 9.5%) most frequently. Students' responses for colors mimicked those that are typical of the limestone or Mississippian-aged chert gravel often used as road metal in the area: brown" (47.6%, 48.2%, 46.6%) and gray (40.4%, 60.7%, 50.7%) were chosen repeatedly. Some students could not think of a geological object or landform with which their town was associated; however, students who did respond typically stated "river," "bayou," "farmland," "salt," "swamps," or "petroleum." Because of these responses, we modified instruction to build upon the petroleum and salt industries in classroom discussions. Although atypical for the physical geology and earth science classes, students were introduced to the ancient conditions that were responsible for petroleum and salt accumulation. Students also explored the interconnectedness of these processes.

One discouraging result was that many students did not feel they had an earth mentor while growing up; 50.0%, 48.2%, and 60.8% of students responded that no one served as such a mentor. Encouragingly for us, students who did identify a mentor chose a teacher more often than any other response (19.0%, 21.4%, and 15.0%).

We were impressed by the quality of the stories that students composed for Part II of the GSP. The teacher was able to use many of these stories, as well as the responses from Part I, as portals through which class-tailored instruction could be delivered during the semester. At the end of the semester, most students constructed interesting and insightful connections in Part III of the GSP between their childhood experiences and the provided concepts of plate tectonics, the rock cycle,

and geologic agents. However, some students did experience difficulties connecting plate tectonics with their past experiences (Pilot A = 31.0%; Pilot B = 35.7%; Pilot C =35.1%), which indicated to the instructor that more emphasis on plate tectonics tied to the local geology was needed in future classes.

Content analysis (Neuendorf, 2001) and database analysis of all students' GSP template responses (n = 235) revealed three conclusive findings. The GSP template (a) helped students to reconnect to their experiences with the earth in their youth (92% of the total responses); (b) helped students to reactivate past emotions associated with geological processes from their youth, such as those evoked by past experiences with wind and water (62% of the total responses); and (c) helped students to recognize and answer their probing earth-related questions they had posed while in their youth, and which they now recalled (80% of the total responses).

Finally, students in all three pilot studies believed that the GSP was useful to them for enhancing geoscience content learning during the semester. Only 8.9%, 18.6%, and 12.0% (in Pilots A, B, and C, respectively) believed that the GSP served no useful purpose to them in their courses. More typical responses from the anonymous, end-of-semester survey included the following:

> *Pilot A*: "Yes, it helped me get in the 'geology zone'"; "Yes, it made me realize that geology is a part of everything I see and that I had been involved in geological processes throughout my childhood"; "It was long, but it made me understand that geology has more to it than just rocks."
>
> *Pilot B*: "I really liked this activity! It did help me to connect all my concepts that we went over in class"; "I thought that it was a great idea because when I took the quiz, I felt as thought I was seeing the things that we were going to learn over the semester. It also helped by making connections with other things that we learned about"; "The . . . survey helped to get me thinking about the things I already knew about Geology, and the things I did not know so much about. Throughout the semester, I have reflected back on what I wrote about, which helped me to construct upon my prior knowledge. Now thinking back on my answers, I realize how much I have learned over the semester."
>
> *Pilot C*: "Yes, it did because thinking of all the things that I have seen in my past relates to geology: the rocks, the rivers I used to play in, the looking at the moon at night with [its] gravitational pull and everything else. THANK YOU"; "In a way I feel the survey helped me to remember some of my past experiences with the Earth and Geology. I am ashamed to admit that before I took this class I really had a narrow mind about Geology. I had no idea that so many things were connected with this subject"; "When taking the [GSP] survey, I reflected upon my past experiences with the geology of the earth. Now having completed the course, I now know how some of my favorite geologic processes occur."

Student responses in both Part III of the GSP and the anonymous end-of-semester survey indicated that the GSP not only helped students to reconnect with the earth interactions of their youth, but also provided a rough outline of the material to be presented during the course when students skimmed chapters and reflected on possible associations in their own lives. Students also reported that their horizons were expanded with the GSP, since many of them had a strict, or inappropriate, definition of geology or earth science when they entered the classroom.

Conclusions

Although the implementation of the GSP requires an investment of classroom time at the beginning of a course, we feel that the time we spent compiling and analyzing our students' GSP responses was time well spent. Student responses from Parts I and II served as a diagnostic assessment to better inform us of our students' incoming geoscience knowledge, their personal interactions with the earth and its processes, and their feelings towards some of the geological processes and products we would be discussing during the semester. We did find some similar responses among classes in Part I of the GSP (perhaps because of similar student backgrounds), but the stories that emerged from the students in Part II were unique to each class. Therefore, we think that the GSP provides a distinctive cornerstone within each class upon which the instructor can build a community of "earth scholars." Responses are typically class-specific, and the instructor's incorporation of the student responses within the course forms the basis for new knowledge integration, as well as the opportunity to make the students shareholders of data within the classroom.

Although there is some variation between pilot studies as to student perception of the value of the GSP, we are encouraged that less than 20% of students in any of the pilot studies felt that the GSP was not a useful tool in the geology classroom. Differences for Pilot C responses may be explained by the fact that the class composition consists of non-science majors, and not elementary education preservice teachers. However, the differences noted between Pilots A and B are perplexing: The class composition was similar, although Pilot A was conducted in the Fall semester and Pilot B in the Spring semester. More research is needed to determine whether this variance is replicated in future classes, or whether Pilot B represents outlier values of student perception.

From shoreline erosion processes to mountain-building events, from rock collections to birthstones, and from intriguing earthquakes to volcanic eruptions, we found that the answers supplied on Parts I and II of the GSP provided potential teaching opportunities with which to connect with our geoscience students. As Marshall McLuhan is widely acknowledged as saying: "There are no passengers on spaceship earth. We are all crew." Our students' past experiences with our planet form the base upon which their intellectual, psychomotor, and affective geoscience education must be built. Our research suggests that the GSP may provide an opportunity to effectively ascertain your own students' backgrounds, and utilize them in your geoscience classroom instruction.

Authors' Note: Additional resources may be accessed at our research group's website, http://EarthScholars.com .

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Students' Alternative Conceptions

Students' alternative conceptions have been variously called misconceptions, prior conceptions, preconceptions, preinstructional beliefs, alternative frameworks, naive theories, intuitive ideas, untutored beliefs, and children's science. The tasks in this regular section of *SER* are based on the literature and may be used at the beginning of a constructivist learning segment to arouse the curiosity of students and to motivate them, while simultaneously eliciting their ideas or beliefs. They are designed to address areas about which students are likely to have an opinion, based on personal experiences and/or social interactions, prior to a specialist learning sequence, or areas that might be considered important for the development of scientific literacy.

Our Natural World

Science Beliefs Quiz (n.d.) provides a 47-item, web-based test of conceptions concerning aspects of the natural world, including plants, animals, motion, forces, electricity, light, electromagnetic radiation, energy, heat, density, particles of matter, temperature, atmospheric pressure, humidity, clouds, magma, earthquakes, rocks, day and night, phases of the moon, seasons, dissolving, boiling, chemical reactions, and condensation. Stein, Barman, and Larrabee (in press) includes information about the reliability and validity information of the instrument.

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Science Beliefs Quiz. (n.d.). Retrieved July 19, 2006, from https://www2.oakland.edu/secure/sbquiz .
Stein, M., Barman, C., & Larrabee, T. (in press). What are they thinking? The development and use of an instrument that identifies common science misconceptions. *Journal of Science Teacher Education*.

Teaching Techniques

This regular section of *SER* describes thinking, cooperative learning, and other teaching techniques.

The Formula Triangle

By: Delma Clifton, Central Queensland University, Mackay, Queensland, Australia
d.clifton@cqu.edu.au

The following technique involves the use of an aid to manipulate mathematical equations, especially in Chemistry, and also represents a critical incident in my teaching career. The aid was passed to me by a student, who had presumably been given it by a teacher to assist her to derive equations for solving various formulae. I have adopted and adapted it in teaching Introductory Chemistry as a bridging course for first-year university students.