GEOLOGY OF VIRGINIA FOR TEACHERS AT RADFORD UNIVERSITY

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Abstract

The Radford University version of the Virginia Earth Science Collaborative's *Geology of Virginia* was taught during Summer 2006 and 2007, and was entitled, *Geology of Virginia for Teachers* (*GEOL 691*). A total of eighteen teachers, primarily from southside and southwestern Virginia, attended the class. The goal of the course was to provide essential knowledge and advanced skills in geology in general, and the geology of Virginia in particular. The course had a strong field emphasis, using Virginia as a natural teaching laboratory to illustrate such concepts as plate tectonics, rock interpretation, and Steno's Laws. Lectures and lab activities were used to guide and inform the field trips, and to provide an overall "big picture" of the time and scale of geology. Maps and materials provided in the course, plus samples and pictures collected by the teachers, created a wealth of materials that can be used in teaching. Teachers developed final projects that highlighted the geology of their home counties. The course featured the experimental use of "podcasts" as a way to deliver content to geographically dispersed teachers. Evaluation results show that teachers gained substantial geologic knowledge, and felt better prepared and more confident in their own teaching.

Introduction

Geology of Virginia for Teachers was developed and taught in conjunction with the Virginia Earth Science Collaborative (VESC) as part of the grant entitled, "Virginia Earth Science Collaborative: Developing Qualified Teachers" and was administered by the MathScience Innovation Center (formerly the Mathematics & Science Center) for the Virginia Department of Education as part of the federal No Child Left Behind legislation of 2001. The primary purpose of the grant was to deliver the core courses in earth science (*Astronomy*, *Oceanography*, *Meteorology*, *Physical Geology*, and *Geology of Virginia*) at multiple sites throughout the state to teachers seeking endorsement in earth science. The primary population of teachers served was teachers who had an original endorsement in a science other than earth science, but who are now seeking add-on endorsements in earth science. A consortium of universities—Radford University, University of Virginia, James Madison University, George Mason University, and the College of William & Mary—collectively know as the Virginia Earth Science Collaborative (VESC) partnered with the MathScience Innovation Center of Richmond to deliver the course at multiple sites throughout Virginia during Summer 2006 and 2007. Radford University was responsible primarily for the southwest and southside Virginia regions.

Although most of the courses were designed for teachers new to earth science, *Geology of Virginia for Teachers* (*GEOL 691*) was slightly different from the other courses offered in that it is an advanced course. Thus, many teachers accepted for enrollment were already endorsed in earth science, and were using the course for recertification or to advance their own knowledge. In 2006, nine teachers were enrolled, while in 2007 an additional nine teachers were enrolled.

Course Development

The course was developed through a long process of collaboration with geologists from the geology faculties from Radford University, James Madison University, George Mason University, the College of William & Mary, and the MathScience Innovation Center. Both *Physical Geology* and *Geology of Virginia* were conceived as a sequence, having a common origin, and with many of the same geologists developing both courses. *Physical Geology* was the introductory course for teachers with little background in geology, and *Geology of Virginia* was the advanced follow-up course that built on the skills and knowledge of the first course.

The group felt it was desirable to have a common syllabus for the sections of the courses taught at different sites across the state for several reasons. It allowed teachers who took *Physical Geology* at one university to take the *Geology of Virginia* at a different university with minimal disruption. It also created the same baseline of knowledge and experience for all teachers and thus made the assessment of the program much easier to administer. Considerable flexibility, however, was built into the syllabi since the courses were designed to take advantage of the local field geology surrounding the teaching locations, which varied within Virginia.

The courses also needed to fit within a certain time frame so teachers could schedule two or three VESC courses over a summer without time conflicts. It was decided that the geology courses would have to be taught in a ten-class, day format for seven hours per day (9 A.M. to approximately 4 P.M.), including a lunch hour. The daily activities included a mix of lecture, indoor lab activities, and outdoor field trips so that the day was very intense, but the time passed very quickly.

It was decided that an overall concept for both courses should be worked on first (early Spring 2005), with detailed planning for the individual courses to follow (*Physical Geology* in late Spring 2005; and, *Geology of Virginia* in Spring 2006). The collaborating geologists met periodically either in person (often at the MathScience Innovation Center) or by teleconference. Over approximately eighteen months of development for both geology courses, professional

relationships and friendships were established, and the collaborating group proved to be quite effective in creating common syllabi.

The process began with an examination of the "Earth Science" section in the Virginia *Standards of Learning* (*SOL*) [1]. The geology content of the *Standards* was carefully parsed and arranged in logical sequences. Some of the more elementary concepts (rocks, minerals, and processes, etc.) served as foundation material that logically went into the *Physical Geology* course. Concepts from the *Standards* that are explicitly Virginia specific (geological provinces, economic resources of Virginia, fossils of Virginia, etc.) were placed in the *Geology of Virginia* course. Although the *SOL* were taken as a guide to the courses' contents, it was felt by the collaborators that teachers need to understand information in far greater depth if they are to teach, explain, and design materials for their students.

Complicating the matter is the fact that Virginia's geology is highly complex, and to truly understand it requires a deep knowledge of geologic time, plate tectonics, and skills in interpretation of geologic information. Much of the geologic history of Virginia is also a history of the Appalachian Mountains, the history of two supercontinents (Rodinia and Pangaea), and two oceans (Iapetus and Atlantic). We wanted teachers to develop skills in geologic interpretation: how to squeeze all the information possible out of rocks and structures, and how to dig down to find the "unwritten" information from geologic maps. It was felt that it was important for teachers to develop these skills, as these are what professional geologists use to critically think through scientific information to draw conclusions. The thinking skills translate very well to teaching, in that teachers can use the rocks and maps of their home areas to tell the geologic history of their regions, and it raises their level of expertise above that of a conveyor of information to that of an "expert." Teachers could use the familiar surroundings of their home counties to illustrate the complexities of Virginia geology.

It was also strongly felt among the group that the *Geology of Virginia* course should have as strong a field focus as possible. Even though it is often not possible to take high school students out for extended field trips, it was felt that teachers would benefit greatly from this experience. Only in the field does one get the feel for geologic scale and geologic time. The correlation between what is listed on paper in the *Standards of Learning* and what is actually there in the real world is often transformational for teachers. It generates enthusiasm and confidence in the teachers which in turn creates enthusiasm and respect in their own classrooms.

The course was clearly geological in focus, designed and built by geologists. However, to work in pedagogical aspects for the teachers, the group decided to require a final project that teachers would design based on their own needs in the classroom or local geology around their schools. The project would build on knowledge gained in the class and would be completed at home in the month or two after the conclusion of the campus part of the course. The course itself offered many opportunities to collect samples, take photographs, and adapt easily converted laboratory exercises to high school use. Most importantly, there was to be a second instructor with K-12 experience that would serve as the bridge between the geological course content and classroom.

With this in mind, the collaborating geologists decided on the following ambitious course objectives:

- Identify common rocks and explain their origin in terms of the rock cycle, concentrating on major sediment and rock types in Virginia;

- Describe the distribution, origin, and economic and environmental importance of renewable and non renewable resources in Virginia (ES 6abc, ES 7);

- Analyze geologic maps, cross-sections, and outcrops for the purpose of describing rock sequences and geologic structure, and interpreting geologic history using topographic, structural, petrologic, and historical relationships;

- Explain basic plate tectonic processes, infer past tectonic settings from relationships in the geologic record, and analyze evidence for specific plate tectonic processes in Virginia (ES 8a);

- Synthesize the sequence of geologic events from geologic maps, cross-sections, and/or outcrops applying information from both relative and absolute dating methods;

- Describe the origin, development, and relationships of the physiographic and geologic provinces in Virginia and synthesize the geologic development of Virginia from the geologic, paleontologic, climatic, and marine records (E8a);

- Utilize the tools and techniques of geologists in an authentic way (e.g., record notes in field notebook, make detailed observations and give interpretations that are based on the observations, and read topographic and geologic maps); and,

- Develop and implement inquiry-based lessons that reflect an increased capacity to engage and stimulate students in a confident and reflexive manner.

In May 2006, the collaborating group met to discuss a common syllabus for *Geology of Virginia*. Since we all hail from different parts of Virginia, we all had our unique perspectives of Virginia geology. Unfortunately, there is no standard textbook on Virginia geology nor is there a standardized curriculum for college courses. All of the most recent information is available only in the professional literature. It was evident that the different versions of the course taught at the different sites across Virginia would have their own unique perspectives, stressing the local geology and the expertise of the instructor. However, no matter where or how the course would be taught, the group agreed on a basic list of topics: geologic time, geologic methods in dating rocks, rock interpretation, plate tectonics as applied to Virginia, economic and environmental geology of Virginia, and a province-by-province look at Virginia's geology with a grand summary at the end. The first half of the course would incorporate aspects of an historical geology course applied to Virginia with numerous local field trips to illustrate points, building on the knowledge the teachers gained in the previous course, *Physical Geology*. The second half of the course would concentrate more on the geological provinces, and would feature an extended trip to visit more distant parts of the state. The group freely shared classroom activities, syllabi, and teaching philosophies.

After the instructors agreed to the general course outline, the Radford University (RU) instructors began to construct their version. Southwest Virginia poses some special problems and advantages. Teachers were spread out over a wide geographic area, with teachers from as far away as southwest Virginia, southside Virginia, the Roanoke Valley, and to the northwest in the Covington area, thus necessitating long drives to campus. The bulk of the teachers chose to take advantage of the RU residence hall facilities and dining services. On the other hand, opportunities to view local rocks and structures in the field are outstanding and abundant. The all-day class format worked in the schedule's favor; the class could go on extended field trips for a half-day or a full day, and could, in theory, be scheduled to follow-up and reinforce lecture and classroom activities. However, a trip to the Coastal Plain is a two-day, overnight affair, a disadvantage compared to a course based in Northern Virginia, for example, where one can drive from the RoanokeValley and the Blue Ridge to the Coastal Plain in less than two hours.

The issue of compressing the course into a ten-class, day format time frame was the most difficult to overcome. In 2006, the course was taught in two calendar weeks, beginning on Monday and ending on Friday of the following week with one break for a weekend. The

disadvantages of this kind of scheduling are the following: 1) it is physically and mentally demanding of everyone; 2) there is little time for study and reflection of the complicated course material during the two weeks; 3) there is little time for grading and returning assignments to provide important feedback; 4) the ideal of having field trips following lecture and classroom activities was not always possible; and, 5) unlike a standard semester where students have the option to work on assignments on their own time over a week or more, this class required that most activities be completed during class time.

Reacting to feedback from the teachers and the instructors from the previous year, it was decided in 2007 to begin the class on a Wednesday, and finish the course on a Tuesday, thus taking advantage of two weekends within the course schedule. This schedule change, in the view of the instructors, was greatly beneficial. First, having two weekends allowed for more classwork to be graded, returned, and reviewed promptly. The new schedule allowed better sequencing of the material. For example, the Blue Ridge geology was covered in class before we studied the Blue Ridge at Mount Rogers, unlike in 2006. Overall, the course was more streamlined and tighter, with the material flowing better between the classroom activities and the field trips.

Podcasts

Unlike *Physical Geology*, where all teachers were presumed to possess little geology background, *Geology of Virginia* course also included some veteran endorsed earth science teachers. However, from the teacher profiles collected by the MathScience Innovation Center, it was evident that many of the veterans had taken their *Physical Geology* course many years prior. To address the issue of uneven geology background knowledge, it was decided to incorporate a distance learning component to the course. The purpose was to provide the teachers with content modules that they could study before arriving on campus, thereby providing both refresher material and important background information to them. This would help level the field between experienced and inexperienced teachers, and between those who had more current knowledge of geologic concepts and those who did not. Radford University (RU) had recently teamed with Apple® computer to make RU an "iTunes® University," featuring "podcasting" as an educational tool. Podcasting has the following advantages: 1) it is asynchronous, so that teachers are not tied to a specific time and place they need to be in order to participate; 2) it is very portable, so that sound files in the MP3 format could be played on any computer, on a handheld device such as an iPod®, or burned onto a CD as audio files to play in a car; 3) it is easy for teachers to download the files provided they have a fast connection; and, 4) if teachers have iTunes® (a free program from Apple® computer that runs on both PC's and Mac's®) installed on

their computers, they can view the "enhanced" versions of the podcasts which include photos and graphics.

A script was written for each podcast, and a voice track was recorded based on the script with music and sound effects sparingly added for humor and drama. Graphics were included in the form of photos or line drawings. The mixing of voice, background music, sound effects, and the visuals was done by *GarageBand*® software from Apple® run on a Macintosh® computer. Each podcast was approximately twenty to thirty minutes long.

Three podcasts were created for 2006: Geologic Time, Geologic Principles (Steno's Laws), and Rock Interpretation. Three additional podcasts were created for 2007: Structural Geology, Plate Tectonics, and "Road Trip." This last podcast was a simulated drive westward on Interstate 64 from the Coastal Plain in Virginia Beach to the Appalachian Plateau in West Virginia complete with maps, air photos, and honking horns.

Materials Used

Unlike the other courses offered through the grant, *Geology of Virginia* is rather specialized, and the materials available depend on the instructor of the course and the location of the course in Virginia. There is no currently available textbook that is up-to-date or organized in a way that is useful for coursework. It was agreed by the collaborating group that the best substitute for a textbook would be the *Geologic Map of Virginia*, published by the Virginia Division of Mineral Resources [2]. It is a large map that is suitable for mounting on the wall of a classroom, and contains enough detail that it takes considerable skill in interpreting the fine points of the geological information. Since 1993, new information, particularly about the Piedmont province, has become available and it was up to the instructors to fill in those gaps. As a complement to the geologic map, we also supplied a shaded relief map (available from the U.S. Geological Survey) of the same scale as the geologic map showing topography. In 2006, we also supplied an historical geology lab manual [3].

Classroom Activities

To address the issue of having a more teacher-friendly approach to classroom activities, many of the activities were designed specifically for this course. Other exercises were based on regular undergraduate courses.

Lab activities included the following: relative dating (using basic geologic principles to unravel the order of events as depicted in cross-sections); the Geologic and Topographic Map of

Virginia (identifying province boundaries, structures, and geologic history as seen on maps); rock identification (using mostly rocks from Virginia, with the rocks arranged according to chemical composition and origin); color cards (each teacher was in charge of the geologic events of a geologic period, with the events written on colored index cards which were assembled to form a geologic column and served as the grand summary of the course); and, indoor geologic mapping (using colored index cards and holders to simulate rock outcrops, a classroom was transformed into a model of the crust from which structures could be mapped).

Field Experiences

Field trips were considered to be the main attraction of the course. Focusing on the geology of Virginia, the routes were chosen to illustrate the classroom material. Typically, for each stop on the field trip, there was some free time for teachers to look around, then the instructor gathered the class together to point out and focus on certain features. This was followed by a question-and-answer exchange among the teachers using the field guide. At most stops, there was a "big picture" spiel to provide important background not obvious from the outcrop itself, and to explain why geologists think this particular place is important. Many stops featured activities: identifying and describing rocks, analyzing the structures to decipher geologic history, or thinking exercises where teachers had to work out the answers to geologic questions based on what they saw at the site. Picture taking and specimen collecting were encouraged, and many teachers took full advantage of this to stock up on classroom samples.

Each field trip included a detailed field trip guide that contained background information, maps, directions to stops, and activities and questions to answer at each stop. Considerable time and effort went into creating the guides. The field guides collected information that is not readily obtainable from books or the Internet, and provided a detailed record of what the teachers did and saw, an important resource considering the lack of a textbook.

The field trips included the following locations: Floyd County (a follow-up on the rock identification lab where teachers examined rocks from all major classifications); Mount Rogers (a full day trip to study the unique volcanic and glacial history of that part of the Blue Ridge and to take in the views from Whitetop Mountain, the second highest peak in Virginia); Giles County (the stratigraphic history of the Valley and Ridge); Price Mountain (structural geology of the folding and faulting of the Valley and Blue Ridge near Blacksburg, Virginia); Blue Ridge-Piedmont-Coastal Plain in 2006 (a two-day trip across Virginia with stops in Roanoke, Lynchburg, Willis Mountain, Arvonia, Richmond, and Williamsburg); Piedmont-Coastal Plain in

2007 (a two-day trip across Virginia with stops in Fairy Stone Park, Martinsville area, Danville, South Boston, Petersburg, and Richmond); and Giles County again (karst geology).

Applications to the Classroom and the Role of K-12 Faculty

The Radford course was fortunate to have had, as the K-12 faculty member for both 2006 and 2007, Cheryl Rowland from Blacksburg High School, a veteran teacher with more than twenty-five years' experience. Ms. Rowland was a tremendous addition to the class. She was instrumental to the planning process and provided feedback for the Radford version of the course. While the podcasts were being developed, she served as a "guinea pig"; Ms. Rowland provided valuable input by using the prototype instructions and critiquing the podcasts in advance of the course. It was her approval that encouraged us to continue using the podcasts.

During the course, she lent her considerable expertise by supplying the class with her "A list" of tried-and-true activities. She was able to speak to the class on such topics as the *SOL*, high school textbooks, and dealing with problem students. Because she had different responsibilities from the course professor, she was able to watch the teachers and provide individual help for those who seemed to struggle. The teachers saw her more as a peer than as an instructor. At the end of every day, there was a short conference about how the day went, what worked and what didn't, and what to do the next day. She was also of invaluable assistance by seeing to the many day-to-day small details and tasks required by a course this complicated.

One of the major assignments of the course was the "final project." In 2006, each teacher was asked to reflect on the course material and write a half-page proposal of how they would develop an experience for their classes that reflected the geology of their home counties. The proposals were reviewed by the two instructors, then returned to the teachers with suggestions and comments. The teachers continued to work on the projects at home during July and August, then mailed them back to Radford where they were evaluated and returned with more suggestions for improvement. We encouraged field-based activities, and many of the projects took advantage of their local geology. Some examples of the projects were the following: a guided field trip to Wasena Park in Roanoke; a scavenger hunt at Buffalo Mountain in Floyd County; collecting rocks along the Jackson River to evaluate how far the rocks had traveled and from where they had eroded; and, having students who live throughout Pittsylvania County collect one or two rocks from their area to bring to class. During the Fall Follow-up session, each teacher did a ten-minute presentation on their project in class. This proved to be one of the highlights of the session. Teachers eagerly collected handouts and ideas, and provided enthusiastic and constructive feedback to strengthen the projects.

In 2007, in keeping with the emphasis on virtual field trips by the MathScience Innovation Center, we asked the teachers to pick a site within their home counties and build a digital presentation complete with photos, maps, and geologic information in the form of a web page or *PowerPoint* presentation that could be submitted to the MathScience Innovation Center website. Alternatively, we also allowed the teachers to submit a lesson plan or a classroom activity if they felt that this would be more beneficial to their teaching. Teachers submitted their work electronically, and the instructors provided feedback in the form of supplemental geologic information, and suggestions for clarity. Most teachers incorporated the suggestions for their presentations during the Fall Follow-up.

The virtual field trips were generally of high quality and included the following destinations: the geology of the Danville area, The Breaks Interstate Park, Natural Tunnel State Park, and James River Park in Richmond. Classroom activities included model building of geologic features, a classroom *PowerPoint* presentation of Blue Ridge geology, and a series of posters showing photos and actual rock samples of Virginia rocks of different ages.

Evaluation Methods

Several evaluation methods were used for different aspects of the class. There were numerous assignments that were included as part of the course grade. These included the following: certain parts of the field trip handouts where the teachers answered questions or completed an activity; lab activities (relative dating, the *Geologic Map of Virginia* activity), the final project, and the post-test.

There was a systemwide evaluation tool developed by the collaborating geologists in the form of a pre-/post-test. The questions sought to gauge teachers' knowledge both in general geology (to provide a baseline of data of prior geologic knowledge), and in Virginia-specific geology. This assessment included some activities and puzzles to see how well teachers could do certain things (e.g., rock identification) or think logically (interpret maps and interpret a relative dating block diagram). The pre-test was the same as the post-test, and the grade of the post-test was included as part of the final course grade. The same pre-/post-test was used in 2006 and 2007.

There was also a course evaluation form that was administered during the Fall Follow-up session. The course evaluation was based on what was used at JMU with additional Radford specific questions. Also, there was a more free form general discussion during the Fall Follow-up

where the class discussed some of the basic issues they faced in finding endorsement and recertification courses to take in southwest Virginia, and what improvements they would like to see in future versions of the course.

Performance of Participants and Instructors

Overall, the class performed very well and evaluated the course highly. The pre-test average in 2006 was 48% (high of 76%, low of 0%—someone handed in a blank or didn't hand it in at all, so the 48% excludes the 0% score), and in 2007 the pre-test average was 47% (high of 68%, low of 37%). Some observations about the pre-test: overall scores were low on all aspects of the test including both Virginia specific questions (which was expected) and the more general geology questions regardless of past teaching experience. Teachers performed particularly poorly on the thinking/process oriented questions, such as calculating a plate tectonic rate, making sense out of a grain size distribution map, and most distressingly, the rock identification part. Considering that many of the teachers were experienced at handling rock samples during their own teaching, we concluded that teachers probably knew their own teaching samples, but they couldn't identify samples they hadn't seen before; hence, their actual rock identification skills were rather low.

The post-test average was 75.5% in 2006 (high of 97%, low of 39%), with everyone improving, some dramatically so; and in 2007, the average was 70% (high of 91.4%, low of 52.1%), with again, everyone improving, some substantially so.

Since there were only nine teachers in each class, the scores reflect not only overall improvement, but also some of the quirks of the individual teachers. For example, in 2006 one teacher who had little geology background, but was working toward endorsement and had not taught earth science yet, scored 19% on the pre-test and 75% on the post-test—an astounding improvement. The teacher with the 39% post-test grade in 2006 (whose grade was anomalously low) was the same previously mentioned person who didn't hand in the pre-test.

It was also our impression that there was a larger subset of academically weaker teachers in 2007 than in 2006, and this was proven by the grades on the post-test. There was a distinct cluster of three grades at the bottom of the class in 2007 (in the 50% range) that all belonged to experienced teachers, while the inexperienced teachers had better grades, a reverse of what one would normally expect if one simply correlated experience level with grades.

The biggest improvements on the post-test came on the Virginia specific questions, especially in the multiple-choice part of the test. The general geology questions, the rock identification section, and the block diagram were substantially better, showing an overall improvement in background geology and basic knowledge.

The results of the course evaluation administered during the Fall Follow-up session were overall very positive and reflected the nature of the course—it was a fast-moving, and mentally and physically challenging class, with complex material that was presented along with the latest data and theories. In 2006, of the seven responses to the course evaluation to the question, "I understand more about the nature of geology and the geology of Virginia," five answered "very true of me," two answered "somewhat true," and no one used the negative or neutral choices. The breakdown of this same question in 2007 from six responses was the following: three "very true," two "somewhat true," and one "somewhat untrue." In 2006, to the question "this course made me think," four answered "very true," three answered "somewhat true," and no one chose the neutral or negative options. In 2007, four answered "very true" and two answered "somewhat true." For choice of material, teachers overwhelmingly felt that topics chosen in the course were "very correct" or "quite correct," so we conclude that the teachers received the geology knowledge they desired. As previously mentioned, in 2006 the two-week time frame caused scheduling compromises, and we were rated less highly on the sequencing of the topics, with "somewhat clear" as the most common choice—a positive answer, but not the highest. In 2007, when the ten days of the course were spread over three weeks, we improved our evaluation results with "somewhat clear" and "very clear and logical" as the most common answers.

In 2006, participants were asked to respond to the statement, "I believe the information I learned from this course will be useful in making future instructional decisions." Six teachers answered positively, "very true" or "somewhat true" (some teachers teach middle school where this material is less relevant). In 2007, the response breakdown was as follows: one "very true," three "somewhat true," one neutral response, and one "not true of me" (this will be explained in more detail below). In both 2006 and 2007, an overwhelming majority answered, "very true" or "somewhat true" to the question, "I feel more confident discussing the geology of Virginia with my students."

On a scale of 1-5 (5 being the highest), the course was rated a 4.6 in 2006, and a 3.8 in 2007; the instructors' rating was 4.7 in 2006 and 4.2 in 2007.

Lessons Learned and Recommendations for Improvement

The two-week time frame of the 2006 course was considered by the instructors to be the toughest aspect of the course, and feedback from the teachers reflected this as well. Despite having rearranged the schedule in 2007 to incorporate two weekends within the course and resequencing the topics and activities, there were still a number of problems. In particular, it was difficult to satisfactorily schedule the two-day trip to the Coastal Plain; it is a large block of time that needs to occur late in the course. In 2006, the trip ended on the day before the last day of class, with exhausted teachers having to take the final exam the next day. In 2007, we decided to run the trip on the Thursday and Friday before the final weekend. This allowed teachers to rest and recover over the weekend, then return for the final two days of classes. Although it made sense from an educational standpoint, most of the teachers intensely disliked this change because it meant immediately driving home at the end of the two-day trip.

During the free form discussions during the Fall Follow-up in 2006, several remedies were discussed. One suggestion was to spread the course out over three weeks to allow for three- or four-day weekends. Some teachers wanted a few extra days on top of what was already scheduled to relax the pace of the course, to create more flexibility in the order of material, and to provide even more time for field trips. Some of the teachers, however, especially the ones who were athletic coaches, adamantly preferred the two-week schedule, indicating that two weeks was all the time they could devote.

The second problem was finding the right level of difficulty for the course. This was a very complex issue that involved the academic goals set by the collaborating geologists and the expectations of the teachers, which didn't always mesh. As previously discussed, the 2006 group evaluated the course very highly. As we got to know the teachers, it was evident that this was a mature group, and they more closely followed the "model teacher" envisioned by the collaborating geologists—the ones that desired to be the Lead Teacher in their school division. In 2007, we intended to follow the successful blueprint from the previous year, but the 2007 group had a different personality. This group was comprised of more teachers who simply wanted to learn techniques that would help them teach the *SOL*, and they didn't see the need to acquire an in-depth knowledge of geology. While one teacher in 2007 commented on the course evaluation that s/he would have preferred a class taught closer to the high school level with activities that could be done in class, this was an atypical comment. As previously discussed, it is also telling that the 2007 group underperformed the 2006 group on the post-test despite improvements to the course.

It is difficult to predict what type of personality a class will have. We have observed that year-to-year variations in the class make-up can make a difference in the course evaluations. What works well one year may not work the next, even if the instructors think the course instruction has improved. In terms of performance in the course, the data also suggest that the initial experience level, both in terms of geology knowledge and teaching experience, is less relevant than overall academic fitness and motivation.

Teachers rated the classroom activities and field trips very highly, and this part of the course was its most successful aspect. The ability to experience geology in the field and to get a sense of time and space is an intangible that we hope the teachers will find a way to convey to their own students.

The podcasts were a big hit, and were positively reviewed by everyone who had a chance to experience them. Teachers felt that they were "neat," a pleasant way to learn, and fulfilled the objective of providing background material. We envision that, over time, an expanded series of podcasts can be made and, together with other delivery methods, may serve to cut down on the amount of time people have to travel to class at Radford University, and thus, better serve the teachers of southwest Virginia.

The emphasis on virtual field trips for the class projects in 2007 was very positive. In order to create them, teachers had to get outside their home areas, do some geological thinking on their own, and come up with a product that was informative, creative, and useful. The best of the projects, in particular "The Breaks Interstate Park" and "Geology of Danville," were outstanding.

Conclusion

The evaluation results lead to the conclusion that *Geology of Virginia* fulfilled its stated objectives of boosting the geological knowledge of teachers, filling a gap in the teachers' knowledge of the geology of Virginia, and increasing teachers' skill at analyzing maps and geology in the field, and in critical thinking using "geology-logic." Teachers have expressed increased confidence in their knowledge of geology, and this will translate to changes in how they present geology to their students. They collected many samples and photos that could be used in the field, and have the course materials and activities at their disposal to use in their own teaching. In addition, teachers created projects based on the local geology of their home counties that could be used in their own classrooms. The use of technology in the form of podcasts holds promise as a means to help overcome the challenges of reaching widely dispersed teachers. ■

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