Geology of Virginia for Teachers

Radford University Edition

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Abstract

The Radford University version of “Geology of Virginia for Teachers” course was taught during summers of 2006 and 2007 as part of the Virginia Earth Science Collaborative. A total of 18 teachers, primarily drawn 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 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 of reaching widely geographically dispersed teachers to deliver content. Evaluation results show that

teachers gained substantial geologic knowledge, and feel better prepared and more confident in their own teaching.

Name of course

Geology of Virginia for Teachers (GEOL 691)

Instructors:

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Location

- Radford University, June 19-23, 26-30, 2006; with a Saturday Fall Follow-up session on September 16.
- Radford University, July 11-July 24, 2007; with a Saturday Fall Follow-up session on September 8.

Introduction

"Geology of Virginia for Teachers" was developed and taught in conjunction with the Virginia Earth Science Collaborative as part of the grant entitled "Virginia Earth Science Collaborative: Developing Qualified Teachers" and was administered by the Richmond Math-Science Innovation Center for the Virginia Department of Education as part of the "No Child Left Behind" program. The primary purpose of the grant was to deliver the core courses in earth science throughout the state (Astronomy, Oceanography, Meteorology, Physical Geology, and Geology of Virginia) to teachers seeking endorsement in earth science. Some of these teachers were already teaching earth science but with a limited background, while other teachers were beginning the endorsement process but were not yet teaching earth science. Radford University is one of the partnering institutions and is responsible primarily for the southwest and southside Virginia regions.

Most teachers were recruited from school divisions that signed a participation agreement with the Virginia Earth Science Coalition in which school divisions helped defray the tuition expenses. Teachers from other school divisions were invited to attend as well (on a space-available basis). The Geology of Virginia course was a bit different from the other courses offered since it is an advanced course. Thus, we accepted many teachers who were already endorsed in earth science and were using the course for recertification, or simply as a refresher course.

Teachers received four graduate credits (at the 600-level).

Course development

The course was developed through a long process of collaboration with geologists from other VESC-participating institutions. The original concept of the Geology of Virginia course was to serve as a follow-up to the "Physical Geology for Teachers" course, also taught by the VESC, that would serve as an introduction to geology. The collaborating group included geology faculty from Radford, James Madison, George Mason, William and Mary, and the Richmond Math-Science Center. The group met periodically either in person (often at the Math-Science Center) or by teleconference. Over the 18 months or so of development for both geology courses, professional relationships and friendships were established and the collaborating group proved to quite effective in creating a common syllabus.

The process began with an examination of the Virginia Standards of Learning in Earth Science. 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. Complicating the matter is the fact that Virginia's geology is highly complex, and truly understanding 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 delve down to find the "unwritten" information from geologic maps. It was felt that it was important 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: 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 surrounding of their home counties to illustrate the complexities of Virginia geology.

It was also strongly felt among the group that the Geology of Virginia class should have as strong a field focus as possible. Even though, in present circumstances, 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, both in terms of the sizes of structures, and in examining rock layers in order of their formation, the feel of geologic time. The translation 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 an enthusiasm, confidence, and a 'been there done that' attitude that generates enthusiasm and respect in the classroom.

In May, 2006, the collaborating group met to discuss a common syllabus for the Geology of Virginia course. Since we all hail from different parts of Virginia, we all had our unique perspectives of Virginia geology. Unfortunately, there is no standard textbook in 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 the state would have their own unique flavors, stressing the local geology and the expertise of the instructor. However, no matter where or how the course was to 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 a Historical Geology course applied to Virginia with numerous local field trips to illustrate points, building on the knowledge the teachers gained in the previous Physical Geology course.

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. All of this was to be accomplished in a ten-class-day time frame. The group freely shared classroom activities, syllabi, and teaching philosophies.

After the general outline was agreed on by the instructors from the state-wide group, the Radford instructors began to construct their version of the course. Southwest Virginia poses some special problems and advantages. Teachers are spread out over a wide geographic area, with teachers hailing from far Southwest Virginia, Southside Virginia, the Roanoke Valley and as far northwest as the Covington area, 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. 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 Valley and Ridge to the Coastal Plain in less than two hours.

One of the Radford instructors (Tso) had previously taught a similar class (The Geology Field School for Teachers, Eisenhower Funded, last taught 1998), and knew the geology of the local area and the best field trip routes. In addition, he teaches the undergraduate Geology of Virginia class as part of his normal course load, and thus had lecture notes, Powerpoints, and an electronic image bank at his disposal. However, the teacher class differed from the undergraduate version in a number of fundamental ways. Although the teachers were required to have taken a prior physical geology course, the course may have been taken many years ago, and many of the teachers needed a refresher in geologic basics. A much more hands-on approach to classroom activities was desired so that teachers could adapt course activities to their own classrooms. And importantly, the ten-day structure of the course greatly compresses the learning curve. Unlike an undergraduate course, however, this course had two instructors: a college faculty member and a K-12 faculty member from a local high school. Between the two instructors, the activities were tailored to a way that was more appropriate for this version of the class. The class also met for a full day, thus allowing for longer field trips.

To address the issue of prior geology 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 in the summer. This would provide the teachers with both refresher material and important background information. Radford University has recently teamed with Apple Computer to make RU an “iTunes University”. As part of the arrangement, there were faculty development workshops in “Podcasting” for use in college courses. After evaluating a number of technologies (Web-based video conferences using Breeze, Web-based learning modules based on WebCT) it was decided that Podcasting, despite the newness of the technology, was worth a try. It has the following advantages: 1) it is asynchronous, so that teachers are not tied to a specific time and place they need to be 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 on a CD 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 PCs and Macs) installed on their computers, they can view the “enhanced” versions of the podcasts which include photos and graphics.

The instructor (Tso) was one of the first of the faculty at Radford to create podcasts for instructional purposes. Although there are numerous ways podcasts can be created and used, he used the “radio show” model that features a single voice using an informal, conversational style. 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 across I-64 from the Coastal Plain in Virginia Beach to the Appalachian Plateau in West Virginia.

The podcast creation program used was “Garageband”, an Apple program, on a Macintosh computer. Garageband is basically a sound and music creation and mixing program. A script was written for each podcast, and a voice track was recorded based on the script. Music and sound effects were sparingly added for humor and drama. The Geologic Time and Geologic Principles podcasts included graphics in the form of photos or line drawings. Garageband took all of these elements and mixed them together to form the downloadable computer files. Two versions of the podcasts were created: a straight “mp3” audio only file playable on any computer or portable player, and an enhanced “m4a” file that included graphics that could be viewed in iTunes. Each podcast was approximately 20-30 minutes long, and each took parts of 3 or 4 days to complete, from script writing to recording to post-production and graphics creation.

To address the issue of using a more hands-on approach to the classroom activities, many of the activities were newly designed specifically for this course. For example, using a suggestion from one of the George Mason faculty, the Geologic Map of Virginia exercise employed overlaying the large geologic and topographic maps of Virginia with drafting vellum so that teachers could draw outlines of how they saw the geologic province boundaries based on the ages and patterns on the maps. This was no trivial exercise: teachers had to understand the nature of geologic contacts, the processes involved in placing rocks of one type against rocks of a different type, and the thought process involved in deciphering geologic history from a map. Other exercises were based on what was done in the undergraduate version, but special emphasis was placed on geologic time and rock interpretation (Relative Ages of Events and Rock Identification exercises).

The issue of compressing the course into a ten-class-day 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 that: 1) it is physically and mentally demanding of everyone; 2) there is little time for study and reflection of this complicated course material during the two weeks; 3) there is little time for grading and returning assignments to provide important feedback; 4) to fit in field trips, lectures, and classroom activities requires very tight scheduling without the flexibility that one would have in a normal schedule; and 5) unlike in a standard semester, where a students have the option to work on assignments on their own time over a week or more, in this class, all activities pretty much had to be done and finished during class time.

The field emphasis required special scheduling. For logistical and human reasons, long field trips were avoided on Mondays and Fridays. The trip to the Piedmont and Coastal Plain took two days and it was a challenge fitting the two-day block with the logical sequencing of the other course material. For example, the day after we returned from the two-day trip to the Coastal Plain in 2006 was the last day of class, when the post-test was administered – not the optimum time for a final exam without time for rest and study. However, having full days devoted to a single class can have many advantages. Afternoon field trips were ideal for illustrating concepts from a morning classroom session, this providing near-instant reinforcement, and we attempted to do this as much as possible (the Floyd County trip followed up the classroom activity on rock identification, and the Giles County trip followed the lecture on the Valley and Ridge). However, the ten-class-day limitation created sequencing headaches. For example, the all-day Mount Rogers trip in 2006 was run before the class had a chance to learn about the Blue Ridge in lecture. The visit to the Coastal Plain on the two-day trip always preceded the lecture on the Coastal Plain, typically one of the final topics covered.

In 2007, following up from feedback from the teachers and the instructor's experience from the previous year, it was decided 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 was greatly beneficial in the view of the instructors. First, having two weekends allowed for more class work to be graded, returned, and reviewed promptly. Although long field trips on Friday tended to be avoided, it was decided that the two-day trip to the Coastal Plain was done on the Thursday and Friday of the second week allowing time to rest and recover after the trip and also to think and reflect on the experience, although, as will be discussed below, this was not a popular decision with the teachers. The new schedule allowed better sequencing of the material, and the Blue Ridge geology was covered in class before we went to Mount Rogers, unlike in 2006. Overall, the course was much more streamlined and tighter, with the material flowing better between the classroom activities and the field trips.

Demographics of participants

A total of eighteen teachers participated in the course (nine in 2006 and nine in 2007). They hailed from as far east as Surry County, as far north as Covington and Roanoke, and as far southwest as Lee County. In 2006, five of the teachers were veterans, were fully endorsed in earth science and had taught earth science for a number of years. Three of the teachers were taking the course as one of the last courses needed to complete an endorsement. One of the teachers was relatively new and had at least two more earth science classes to take. Many of the teachers have endorsements in other sciences (e.g. biology, math, general science, history) and came to geology as a secondary endorsement. All were current earth science teachers or were to have taught it fall 2006. Only one teacher has an actual geology undergraduate degree. The 2007 class was similar in demographics. 6 were veteran endorsed earth science teachers and 3 were going for endorsements. Of these three, 1 had already taught earth science for a year, and two were preparing to teach earth science for the first time in the coming school year.

The two classes differed quite a bit in terms of personality. The 2006 group skewed toward middle age (45-60). We observed at the time that this was to be expected and was one of the problems in reaching many of the earth science teachers using summer courses. Because teachers in southwest Virginia are spread out over such a wide area, it is necessary for most teachers to use the residence halls for overnight stays, thus taking them away from families for two weeks. The 2007 group was a younger group, however, with many of the younger teachers feeling the pressure to complete their endorsements as they were shifting from other subject areas (biology, physics) to earth science. The smallness of the class sizes compared to ones offered in Richmond or Northern Virginia still points to the geographic difficulties of attracting teachers spread out over a wide area. Two of the teachers in 2007 were from the Richmond area and came to us because the Richmond version of the course had over-filled.

Materials Used

Unlike many courses commonly offered to earth science teachers (Meteorology, Oceanography, Physical Geology), Geology of Virginia is rather specialized, and the materials available depend on the instructor of the course and the location of the course in the state.

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 is the Geologic Map of Virginia, published in 1993 by the Virginia Division of Mineral Resources. It is a large-sized map that is suitable for mounting on a 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 of the same scale as the geologic map showing topography, available from the US Geological Survey.

A historical geology lab manual (Laboratory Studies in Earth History, 8^{th} ed., 2004, Brice, James C., Levin, Harold L., and Smith, Michael S., McGraw Hill, New York) was also supplied for 2006, although it isn't Virginia-specific, and its use was primarily as a back-up reference, with no actual class assignments from the book. We decided to forgo this book in 2007.

Other materials were used for specific activities. For example, for classroom lectures, the instructors supplemented the lectures with an extensive digital image bank that was presented as PowerPoint slides. The images were collected from numerous sources: personal photos, scanned images from textbooks and journal articles, the Geology of Virginia CD-ROM series published by the Virginia Division of Mineral Resources, and downloaded from the internet. The previously mentioned podcasts were assumed to be already studied prior to arrival at Radford, and although they were referred to during the lectures, they were considered to supply background information and were not specifically reviewed during the ten days of the course.

Every 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. Taken together, the five 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.

For classroom activities, the instructors relied on RU Geology Department materials and exercises developed for undergraduate courses. For example, the relative dating exercise used a standard set of block diagrams that were part of time-tested undergraduate lab exercises. The rock identification lab used large samples from Radford's Virginia rock collection and the specialized Petrology collection. The class used the large Geologic Map of Virginia extensively during lab time (see activity description below).

Course Objectives

The state-wide collaborators, based on a study of the SOLs and their own backgrounds as geologists, established eight goals. Some were content knowledge based, some were based on skill-sets that teachers were to develop, and some were pedagogical in nature.   These goals are listed below:

1. Identify common rocks and explain their origin in terms of the rock cycle, concentrating on major sediment and rock types in Virginia.
2. Describe the distribution, origin, and economic and environmental importance of renewable and nonrenewable resources in Virginia. (ES 6abc, ES 7)
3. 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.
4. 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)
5. Synthesize the sequence of geologic events from geologic maps, cross-sections, and/or outcrops applying information from both relative and absolute dating methods.
6. 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)
7. 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, read topographic and geologic maps).
8. Develop and implement inquiry-based lessons that reflect an increased capacity to engage and stimulate students in a confident and reflexive manner.

These are very similar to the "critical thinking" process professional geologists use to unravel the geology of a particular region. For example, before a geologist undertakes field work, he or she studies previously published work, critically reviewing journal articles and geologic maps. Usually a field project seeks to answer a central question or has a specific purpose, so the methodologies used and how the data was collected and interpreted by previous geologists are carefully considered for relevancy, accuracy, and bias. All information must be put in context of the "big picture" in terms of the geology of the region and plate tectonics. The geologist's own fieldwork involves basic skills in rock identification, note taking, and data gathering. The data and ideas are then synthesized perhaps in the form of a map or journal article which itself is then critically analyzed during the peer review process. The presentation of the data in terms of a talk at a professional meeting or journal article has some parallels with the 8th of the above goals, with the word "geologists" substituted for "students".

However, with teachers in mind, one can add some additional goals that are difficult to quantify but are important nonetheless. In many school divisions, there are only a few earth science teachers – some schools only have one teacher. Thus, many teachers work in a vacuum, and it is important to gather teachers together and have them interact, make contacts, and trade ideas and experiences. Many of the teachers in the Earth Science Collaborative are teachers that came into earth science from a different subject. Many have had only a minimal geology background, and their geology information is primarily "book learned". Some teachers who come from, for example, a physics background might be strong in the astronomy component of earth science, but skimp on teaching the geology part, despite the fact that geology has the strongest emphasis in the SOLs. Even among teachers with a geology background, a course specifically in Virginia geology is not a commonly offered class at undergraduate institutions. Thus, an important goal for the course is to instill a sense of experience and confidence – a "been there, done that" attitude. A field-based class can make this material come alive. The geologic history of Virginia spans approximately 1 billion years and the results of plate tectonic processes are there to see nearly everywhere you look. In traveling from province to province, and seeing how the rocks and structures change as you cross the province boundaries, the physical reality of how geology works seeps into the mind in a way that you feel as though you are actually living it.

Description of Lab Experiences

A description of the lab experiences follows below. Please see the detailed syllabus for scheduling information. Note that due to time considerations, several of the lab activities that were planned were not used.

Relative Dating: This exercise is a geology "classic". One of the podcasts reviewed Steno's laws, and this exercise follows up with a set of block diagrams that serve as geological puzzles. To solve the puzzle, teachers take the various layers and structures and, using the principles of Superposition, Original Horizontality, and Cross-cutting Relationships, and recognizing structures such as folds, faults, and unconformities, tell the relative order of events and construct a geologic history. The type of thinking used to solve the puzzles is fundamental to geologic reasoning.

"What's the Structure": As a follow-up to Relative Dating, and as a precursor for the geologic map exercise, an activity was developed that served as a class exercise in geologic reasoning. Whereas Relative Dating looks at geological puzzles from a side view, geologic maps look at geology from the top view. For example, a geologic map of a circular patch of rock surrounded by other rock can mean a number of things: a map of a hill with flat-lying rocks, a map through a thrust fault, an intrusion, or a sedimentary deposit. The activity was presented as a series of PowerPoint slides of line drawings, with the class discussing each scenario while posing a number of "what if?" type questions.

The Geologic Map of Virginia: This activity made detailed use of the big Geologic Map of Virginia and the Relief Map of Virginia that was supplied to each member of the class. A long handout of questions and activities was supplied with this, and the activity took parts of three days to accomplish. The tables in the classroom were rearranged to provide large working surfaces so that both maps could be accommodated. The teachers were additionally supplied with large sheets of drafting vellum that were overlaid on the maps for tracing features. The first task was to trace Virginia's province boundaries on the vellum based on physiographic criteria using the relief map. Then the teachers transferred the vellum onto the geologic map and drew the province boundaries based on the geologic map. In many cases, the boundaries agree – the Appalachian Plateau has a starkly different geologic map pattern than the Valley and Ridge, and this is easily seen topographically as well. The teachers found out that the Coastal Plain-Piedmont boundary as seen as the "Fall Line" is simple in principle, but on the map, the pattern is far from being a straight line. The Blue Ridge-Piedmont boundary on the geologic map is very different from the geographer's physiographic boundary because there, the geologic boundaries as seen as fault zones do not match the topography. Next, each province was examined in detail. For example, there is a close correlation between folding and topography in the Valley and Ridge, but a topographic depression seen on the relief map might actually correspond to an anticline to create an “inverted” topography. The rocks of the Blue Ridge have a broad fold-like structure, and the Coastal Plain’s rocks are not exactly horizontal, but dip gently to the east. The Piedmont is so complex that it can be divided into a number of “terranes” of rocks that each have their own geology and history. Finally, the teachers studied the geology of their home counties and wrote a geologic history based on what they saw on the maps.

Rock Review: Most of the teachers had taken a previous Physical Geology course, and all had some experience in identifying rocks. In this class, we revisited rock identification, but with a Virginia twist. We used, as much as possible, real rocks from the state, using a set of flow charts to use as identification tools. The flow charts were based on standard identification techniques: hardness, color, grain size, acid reaction, etc., so teachers used the same methods that they used in their physical geology courses. However, the rocks were not arranged in the standard igneous, sedimentary and metamorphic groups, but were arranged in 4 composition groups (quartzo-feldspathic, mafic, pelitic, and calcareous) with each group spread out on its own lab table. For example, on the quartzo-feldspathic table, teachers saw rocks with quartz and feldspar, with granite being an igneous example. They also saw an assortment of sedimentary rocks as well, such as sandstone and conglomerate - rocks that might have been created from materials eroded from granite. They also saw their metamorphic equivalents, primarily gneisses that were at one time granites or sandstones. On the mafic table, they saw some typical basalt (that you would see in a Virginia Mesozoic Basin), notable for its dark color and relatively high density. However, on the same table they had the metamorphic equivalent of basalt - greenstone and amphibolite from the Blue Ridge, also dark in color with a high density. The purpose behind arranging rocks this way was to get teachers to see "before metamorphism" and "after metamorphism" examples of how rocks can change during deformation and mountain building. This information can be used as clues to the history of Virginia. For example, the rocks of the Blue Ridge and Piedmont can be identified as metamorphic rocks, reflecting the process of building the Appalachians. However, they also have a pre-metamorphic existence that hints at their conditions of formation prior to the Appalachians. This part of the thought process that professional geologists use: Identifying a rock is only the first step, but the real questions are where did it come from and how did it get there.

Color Card Exercise: On the first day of class, each member of the class was assigned a geologic time period or era to be responsible for. Each geologic period was assigned a color and each teacher was handed a stack of index cards of the matching color. The assignment was that whenever a rock or event from that period/era was mentioned in a class lecture, turned up during a class activity, or observed on a field trip, the teacher was to note this down on a colored card, with each card representing a separate event. On the last day of class, the cards were collected and served as the basis for the "Big Picture" summary of the geology of Virginia. Part of the complexity of Virginia geology is that different events happen in different provinces simultaneously. Sometimes these simultaneous events are linked: uplift in the Piedmont can result in sedimentation in the Valley and Ridge. On the other hand these events can be unrelated: volcanism in the Carolina Slate Belt happened before it became attached to the rest of Virginia. The cards can be used to show several things. They can be stacked in chronological order to form a sort of geologic column. They can also be spread out on tables to show what was happening in different parts of Virginia. The cards can then be moved around to show how the different terranes and thrust sheets moved during the assemblage of the Appalachian Mountains. This exercise was done class-participation style. After the cards were collected, they were put in chronological order and read back to the class. While doing this, the cards were placed on a large table in a way to mimic different locations. For example, the Mount Rogers cards were placed on the "south" end of the table, the Coastal Plain was put on the east end, and the Carolina Slate Belt was originally put on a different table since it wasn't originally part of Virginia, then moved to the Virginia table when it arrived here. As the various areas moved with respect to each other, the cards were moved around, so that, for example, the Goochland Terrane, originally created somewhere north of Virginia, was pushed southward along the Spotsylvania Fault into its correct location when we reached the late Paleozoic. A dramatic moment came when we reached the Chesapeake Bay Impact when its card was slammed onto the table in its correct location.

Indoor Geologic Mapping (used in 2007): This exercise turns a standard RU geology lab room into a giant geologic map. Color cards and wooden holders stand in for rock outcrops with the cards representing rock formations, and the wooden holders used as a way to position the cards with various dip angles and strikes. Each table in the room has a card bearing a unique set of instructions for various map set-ups. The instructions contain the "geology" for the set-ups, with each table serving as an outcrop location. The "geology" includes information similar to what a real geologist might write in his/her field notebook – the rock formation found at the location (or, in this case, a color card), and its strike and dip. The instructor calls out, for example, "lets do set up #1", and the students read the instructions for set up #1, get the appropriate blocks and cards from the front of the room, and set up the geology of their table. To do so, they have to demonstrate knowledge of strike and dip – the block has to be situated a certain way on the table to reflect the correct strike and dip as represented by the card. Each table is unique, but taken together, all the tables contribute to an overall geologic map pattern. The students then go on a “field trip”, armed with blank maps of the room layout. They visit each “rock location”, mark the rock and the strike and dip on the map, and when finished, construct the map itself, a geologic column, and a geologic cross section. The setups can be made to create complex and ambiguous geology for more advanced students, and some tables can be left with blank set ups (no “rocks” exposed) to represent real conditions of soil and vegetation cover.

This particular exercise was a big hit with the teachers. It requires very little material (colored large index cards, and wooden blocks that have pre-cut slots in them for different dip angles to hold the cards – can be quickly made in a wood shop in school), and can be custom designed for any classroom with tables. Importantly, students have to demonstrate the ability to see things three dimensionally as the structure of the set up is revealed. The tabletop level represents the surface of the ground (or map plane), but one can imagine projecting the structures above the tables (the part of the structure that has been eroded away), and the structure below the tables (the part of the structure that still exists but underground).

Description of Field Experiences

Field trips were considered to be the main attraction for the course. The routes were chosen to illustrate the classroom material, and the geology of southwest Virginia was the star of the show. For each field trip stop, typically, 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, there was some give-and-take, and some questions to answer from 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 thought exercises where the teachers had to work out the answers to geologic questions based on what they see. Picture-taking and specimen collecting were encouraged, and many teachers took full advantage of this to stock up on classroom samples.

Floyd County: This trip follows up on the rock identification lab. The route travels through the Valley and Ridge – Blue Ridge province boundary and visits examples of igneous, sedimentary, and metamorphic rocks. The primary goal was to get teachers to learn how to properly write a field rock description. The stops included: a dolomite quarry with large and outstanding rock exposures, a highly contorted shale on the base of the Blue Ridge Thrust, a stretched and smeared augen gneiss in the Blue Ridge Thrust fault zone, a look at the 1 billion-year old Grenville basement rock, a location where an unmetamorphosed basalt dike cuts across the basement rock (leading to all sorts of interpretive questions), and a former basaltic intrusion now metamorphosed to an amphibole schist. The highlight of the trip was at "Airpoint" along U.S. 221 near

Roanoke. There, against the spectacular backdrop of the Blue Ridge escarpment, is basement rock cut by dikes of two different compositions.

Mount Rogers: This full-day trip was one of the highlights of the course. The trip shows off the unique geology of the Mount Rogers area, including glacial till, varves, and dropstones, several different types of a rare and explosive volcanic rock called rhyolite, and various other sedimentary rocks from the time of 750-550 million years ago. The glacial rocks are quite unusual for non-Pleistocene sediments, and the volcanic rocks are quite hard and form the highest elevations in state. The two highlights include a “trip through time” on the Virginia Creeper Trail, and a hike on part of the Appalachian Trail on Whitetop Mountain (the second highest elevation in Virginia) and Buzzard Rock. The views there were spectacular and one can see far into the Blue Ridge of North Carolina in one direction, and the Valley and Ridge in another direction. The rocks tell the story of the early and failed attempt of rifting of the supercontinent of Rodinia, 200 million years earlier than the later and successful rift that formed the Iapetus Ocean.

Valley and Ridge Stratigraphic Section (Giles County): This trip follows up on the lecture on the history of the Valley and Ridge and how the sequence of rocks, representing pre-Appalachian rocks, followed by sediments eroded off the developing Appalachians tell part of the history of the entire mountain chain. The field trip route was chosen to follow the rocks in chronological order. Thus the trip started with Cambrian rocks featuring the nearly mile-thick sequence of carbonate reefs, followed by sediments showcasing the rise and fall of the first two “clastic wedges” representing the earlier Taconic Orogeny and then the later Acadian Orogeny. The last outcrop was in the youngest rocks exposed in the region, including Mississippian-age coal showing the rise of the land, the drainage of the rivers flowing off the rising mountains, and the retreat of the shoreline toward the inland sea to the west.

Price Mountain: This trip was a close-to-home view of some of the effects of thrusting and folding in the Radford-Blacksburg area. The main attraction is a structure called the "Price Mountain Window", where the Pulaski Thrust Fault has been folded and eroded to expose the younger rocks beneath the fault. These rocks have been folded into a "doubly-plunging anticline" to form a classic oval bull's eye pattern, with the center of the structure being on a mountain-top. The trip route drove around and through the structure and ended on the mountaintop. At the stops, we inspected the rocks, compared them to the geologic map, and noted the orientation of the beds and how they illustrate the folded pattern.

Blue Ridge – Piedmont – Coastal Plain (2006): This was a two-day trip making stops in the Blue Ridge and Piedmont to Williamsburg, its eastern-most destination. The trip included an overnight stay in Williamsburg. The first day was spent as a sort of transect across the Blue Ridge and Piedmont, roughly following the U.S. 460 corridor for part of the way. This included stops at Mill Mountain, at the "star" in Roanoke, the Blue Ridge Parkway, and stops along U.S. 460 to see the Blue Ridge basement, and the 600 million year old sedimentary rocks in Lynchburg. From there, the route wandered northeastward to visit two must-see stops for science teachers: the Willis Mountain kyanite mine, and the Arvonia Slate mine, where teachers were given guided tours and had opportunities to collect samples. From there, we headed eastward along the James River to visit the enigmatic "State Farm Gneiss" and example of 1 billion-year old rocks in the Piedmont (no one is quite sure why rocks of this age are found there). Due to severe flooding, our planned stop to see the Petersburg Granite in Richmond at James River Park had to be cancelled, but it was interesting to glimpse the flooded park. We finished the day by having a group dinner in Williamsburg. The morning of the second day was led by Dr. Gere Johnson of the College of William and Mary. He gave the class an expert tour of the Coastal Plain including several famous Williamsburg area localities (Cornwallis Cave, the Matoaka Reservoir dam) and, we even had an opportunity to collect the state fossil Chesapecten jeffersonius. The second half of the day was spent mostly driving back to Radford, but stops were made in Richmond to view some terrace gravels and Mesozoic Basin rocks, and at Afton Mountain, to view the Catoctin greenstone to gaze eastward at where we came, a concluding stop that bookends the Mill Mountain stop from the previous day.

Piedmont - Coastal Plain (2007): In 2007, three of the teachers hailed from the Danville area, and two of the teachers were from Richmond, so with that in mind, the two day trip was redesigned to spend time in those areas. On the first day, the trip route went south via Route 8 toward southside Virginia, stopping first at Fairy Stone Park, on the geologic boundary between the Piedmont and the Blue Ridge. There, teachers had an opportunity to collect fairy stones (staurolite pseudomorphs) and inspect the province boundary in person. From there, the class traveled to the Solite Quarry in the Danville Mesozoic basin, near Eden, N.C., just on the Virginia-North Carolina state line. The class was met there by Dr. Nick Frazier of the Virginia Museum of Natural History, an expert on the fossils that have been found at the quarry, including dinosaur footprints, plants, and fish. We made two more stops on the first day to visit the ancient "Milton" volcanic rocks in Danville that were formed from a volcanic arc in Iapetus Ocean, and secondly at the Vulcan Quarry at South Boston to visit the "Hyco Shear Zone", a major fault zone within the Piedmont. We drove to Petersburg and spent the night there.

On the second day, the class was met by Dr. Lauck Ward of the Virginia Museum of Natural History at Lee Memorial Park in Petersburg to visit rocks of the Coastal Plain at Lieutenant's Run. There was excellent fossil collecting, including a *Chesapectin* relative of the state fossil of Virginia, and it was a chance to reflect on how high sea level must have been to deposit oceanic rock as far west as Petersburg. Dr. Ward accompanied the class to the Ashland area for a stop at the Carmel Church Quarry where Eocene Coastal Plain rocks are exposed including whale bones and shark teeth. From there, we traveled into Richmond and visited James River Park (not visited the previous year because of flooding), and from there drove to Radford, with a short stop on Afton Mountain.

Karst Geology: This trip was run during the fall follow up session in September. The group ventured out to Giles County and looked at some geologic structures and karst features. The trip included a stop on Gap Mountain to take a closer look at the hard Silurian sandstone that holds up the most prominent ridges of the Valley and Ridge, an exposed fault plane at Newport, Va., Sinking Creek (a large creek that disappears into a cave system), the Eggleston Sinkhole (a large collapse sinkhole that served as a town dump at one time), and some photogenic complex folds in the Moccasin Formation.

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

During the development and planning for Geology of Virginia, it was clear that we would be dealing with a much more diverse group of teachers than for the Physical

Geology course. In Physical Geology, teachers have little prior background in geology and the majority of teachers were new to the subject. For Geology of Virginia, there were people with geology degrees, veterans who had taught earth science for several decades, to newcomers with very little background. The various motivations of why teachers signed up for the course was learned as the instructors got to know the teachers. On the one hand, there were teachers who craved detailed knowledge. They aspired to be their county's lead earth science teachers, and wanted to be the person students and other faculty came to for answers to their questions. On the other hand, there were some who simply wanted to learn techniques that would help them specifically with the SOLs and didn't see the need to know much that was in-depth. The previously discussed lofty goals of raising the teachers' abilities beyond that of a mere conveyor of information to that of expert – some of the teachers wanted no part of that. One 2007 teacher commented on the course evaluation that he/she would have preferred a class taught closer to the high school level with activities that could be done in the class. (This comment was very atypical of comments in general.) One 2007 teacher was in the class reluctantly. She was trained in biology, loved biology, but was forced to teach earth science because of the job situation in her school. We never got the feeling as we got to know her that she was getting into the subject matter, and she always processed her thoughts not through the idea of "isn't geology interesting", but with the idea of "how can I use this in my class." Complicating the issue is the complexity of Virginia geology itself and the realization that one could teach the subject in a superficial way, but to do it justice, one has to take the plunge into difficult material.

With this in mind, in 2006, we asked a question of the teachers in our initial survey. We asked: what emphasis should be placed on content versus pedagogy? Mindful of our charge to teach an advanced geology class with a field emphasis, we suggested 80%-20% content to pedagogy ratio. The survey results from the teachers agreed. The 2006 group was a largely veteran group of teachers who wanted to expand their geological knowledge and to experience geology in the field. We were also aware of the limitations of current secondary school science teaching. Time and resources to take high school students for many field trips are scarce and field trips are rare. We tried to strike a delicate balance. Since the course material was much more advanced and complex than what the teachers would teach their own students, we employed techniques that were effective for this purpose. Thus we never attempted to use our teaching methods as a model for high school teachers to follow for their own students. The short two-week time frame of the course was also a consideration. We felt that by concentrating on the geology, we could do that part very well, but there would not be a lot of time for much pedagogical development such as teacher developed lesson plans. To get around that limitation, we used a final project (see below) that the teachers completed at home in July. On the other hand, the course served as a rich resource for materials and experiences that teachers could draw on for their own lesson plans. Many of the lab activities (such as the map-based labs, the rock identification lab, the geologic time lab), with a little modification, are easily convertible for high school use.

When the 2007 course was planned, we followed the blueprint from 2006, with modifications of the course calendar, as previously discussed, as the remedy for the biggest problem from the previous year. We feel that the course was better taught and smoother in its presentation than the previous year. Most of the teachers from 2006 enjoyed the class and felt the difficulty level was pitched just fine. However, the 2007 group had a different class personality, was generally younger in age, than 2006, and as a group, felt much more challenged by the complexity of the material and would have preferred a more simplified approach.

The Radford course was fortunate to have, as the K-12 faculty for both 2006 and 2007, Cheryl Rowland from Blacksburg High School, a veteran teacher of 25+ years of experience, and former student in the previously mentioned Geology Field School. Ms. Rowland added tremendously to the class. Although much of the initial planning for the course was done by the collaborating state-wide geology group, she was important in shaping and providing feedback for the Radford version, bringing in her own ideas, and shaping what she thought would work and what would not work. While the podcasts were being developed, she served as a "guinea pig", going through the same process we asked the other teachers to follow: download and install iTunes, download the podcasts, figure out how to view them in iTunes, and then provide opinion on the podcasts themselves. It was her "thumbs up" that encouraged us to continue.

During the running of the course, she brought in many of her own class exercises, supplying the class with her "A-list" of tried and true activities. She was able to speak to the class about things like SOLs, high school textbooks, and problems in dealing with students that the college faculty had little experience with. During the classroom exercises, the two instructors circulated around the room helping people. But during the lectures and field trips, she took notes and was interested in learning the material. She was very good at asking clarifying questions. Because she had different responsibilities, she was able to watch the other teachers and provide individual help for people who seemed to struggle. 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. The teachers saw her as much as a peer than as an instructor. Because of the nature of an on-campus, residence hall-based class with a field emphasis, there were many small details to be taken care of and fires to be put out every day (instructional, people-related, administrative), and it takes two people to truly operate a course like this.

One of the major assignments of the course was the “final project”. For 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 collected by the instructors, reviewed (this was one of the instructor’s “homework” in the Williamsburg hotel), and returned to the teachers with suggestions and comments. The teachers then worked on the projects at home during July and had an August 1 deadline to mail them back to Radford where they were evaluated and mailed back with more suggestions for improvement.

We encouraged field-based activities, and many of the projects took advantage of their local geology. Examples of projects with a local geological flavor were: 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 where they had eroded from; having students living in scattered places in Pittsylvania County collect a rock or two from near where they live, bring them back to the class, plot the results on a map, and see if the boundaries of a Mesozoic Basin emerges on the map (project is attached); study the geologic map of Montgomery County and go on a field trip to collect the rocks and observe field relationships; have students go out to various places in Surry County to find sites of interesting geology (rocks, fossils), and to bring the specimens or photos back to the class to serve as the basis for research projects. Other projects included: setting up a matrix of activities in the form of a tic-tac-toe board, and teams of students can choose a path across the board (horizontal, vertical, or diagonal) and complete the activities on the board (activities include field trips, skits, projects dealing with mineral resources of the region such as gold or kyanite, and completing a vocabulary unit); use of the Geologic Map of Virginia to compare Roanoke County sedimentary rocks with those of the Coastal Plain; and by using plaster, create three dimensional models of mountains and mark contour lines on them.

During the Fall Follow-up session, each teacher did a 10-minute presentation on their projects to the rest of the 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 Math-Science 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 that could be submitted to the Math-Science Center website. We also allowed the teachers to alternatively submit a lesson plan or classroom activity if they felt that this would be of more benefit to their teaching. Teachers presented their work back to the class during the fall follow-up meeting in September. Teachers submitted their work electronically, and the instructors provided feedback in the form of questions, supplemental geologic information, and suggestions for clarity. Most teachers incorporated the suggestions for their fall presentations.

The virtual field trips were of generally high quality and included: 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. The teachers creations were constructed not only for the course, but for actual use in their classrooms.

Evaluation methods

Numerous evaluation methods were used for different aspects of the class. The course was for graduate credit and a grade, so there was work to hand in during the two weeks of the course. This included: certain parts of the field trip handouts where the teachers answered question or completed an activity; lab activities (relative dating, the Geologic Map of Virginia activity, the final project, and the post-test (see below).

There was a system-wide evaluation tool developed by the collaborating state-wide geologists in the form of a pre-post test. The questions sought to gage teachers' knowledge in general geology (to provide a sort of "baseline" of data of prior geologic knowledge), Virginia-specific geology, and included some activities and puzzles to see how well teachers could do certain things (there were a few rocks to identify) or think logically (interpret maps and interpret a relative dating block diagram). The pretest was the same as the post test, and the grade of the post-test included as part of the final course grade.

There was also a course evaluation form that was administered during the Fall Follow-up session (it was felt that there wasn't enough time to do it on the last day of class in the summer). The course evaluation was based on what was used at JMU with additional Radford-specific questions added. In addition, there was a more free-form general discussion during the Fall Follow-up where the class discussed some of the basic issues that they faced in finding courses to take in southwest Virginia for endorsement and recertification, and what they would like to see improved on for future versions of the course.

Performance of participants, instructor's performance

Overall, the class performed very well and evaluated the course highly.

The pre-test average on the pre-post test in 2006 was 48% (high of 76%, low of 0% - someone handed in a blank or didn't hand it in at all, and the 48% number does not include the zero) and in 2007 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. Teachers did 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 conclude that teachers probably know their own teaching samples well enough, but they don't do well at samples they haven't seen before and their actual rock identification skills are rather low.

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

Since there were only 9 teachers in each class, the scores reflect not only overall improvement but also some of the quirks of the individual teachers. For example, the scores from one teacher 2006 who had little geology background, who was working toward endorsement, and had not taught earth science yet, was 19% on the pretest and a 75% on the post-test, an astounding improvement. The person with the 39% post-test grade in 2006 (and his grade was anomalously low) was the same previously mentioned person who didn't hand in the pretest. This person struggled in all phases of the course, and despite special attention, seemed aloof and never got into the flow of the course, a distressing fact considering that he has taught earth science for 2 years. Then there was the person in 2006 who neglected to answer the big block diagram (question #3) on the post test, losing lots of points, although she had substantially gotten it correct on the pretest (she had a 17 point improvement despite that). There were no such dramatic personal stories in 2007, but it should be noted the pretest average was somewhat lower than 2006, and the post-test average was also lower, although everyone improved.

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 skills over the pre-test. Certain questions, such as the one on calculating the sea floor spreading rate was not touched on during the course and few people got it right on the post-test.

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 fast-moving with complex material that was presented along with the latest data and theories, that was both mentally and physically challenging. In 2006, of the 7 responses to the course evaluation, to the question “I understand more about the nature of Geology and the Geology of Virginia”, 5 answered “very true of me” and 2 answered “somewhat true” and nobody answered the negative or neutral choices. In 2007, the breakdown this question, out of 6 responses was: “very true- 3”, somewhat true- 2, and somewhat untrue – 1”. To the question “this course made me think”, in 2006, 4 answered “very true” and 3 answered “somewhat true” and nobody answered the neutral or negative choices. In 2007, 4 answered “very true” and 2 answered “somewhat true”.   Reflecting the complexity of Virginia geology, the question about the appropriateness of the content level of the course, in 2006 4 answered “sometimes too high”, and 3 answered “just right”, but nobody answered the negative choice or the extreme “too high” choice. In 2007, reflecting the class profile as previously discussed, 4 answered “somewhat too high”, and 2 answered “too high”. For choice of material, teachers overwhelmingly felt that topics chosen in the course were “very correct” or “quite correct”, so we feel that the teachers got the geology knowledge that they came for. 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 10 days of the course was spread over three weeks, we improved our evaluation results with most answers as “somewhat clear” and “very clear and logical” as the most common answers.

Of the teaching outcomes of the course, to the statement “I believe the information I learned from this course will be useful in making future instructional decisions”, in 2006, 6 people answered positively “very true” or “somewhat true” (some teachers teach middle school where this material is less relevant), and in 2007, 1 person answered “very true”, 3 people answered “somewhat true”, 1 person gave a neutral response, and 1 person answered “not true of me”. Again, we think the differences in the answers reflects the age and experience of the class. The more experienced 2006 group felt more comfortable with the material and saw ways to use it in their classrooms. The younger 2007 group, we believe, felt that the advanced material went too far beyond SOLs, and thus they didn’t see a way to incorporate the information. To the statement “I feel more confident discussing the Geology of Virginia with my students”, the overwhelming majority answered for both years answered either “very true” or “somewhat true”.

On a scale of 1-5 (5 is the highest), the course was rated a 4.6 in 2006 and a 3.8 in 2007, and the instructors’ rating was 4.7 in 2006 and 4.2 in 2007. We would like to add that this result was quite gratifying, especially in 2006, since the teachers were veterans (a tough crowd) and appreciated the efforts of the instructors.

Lessons learned (positive and negative), 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. In the free-form discussion during the Fall Follow-up in 2006, several remedies were discussed. One suggestion was to spread the course out over three weeks (meeting only 3 or 4 days a week). The advantage of doing this would be to build in some rest and study time, and to give the instructors' time to grade work and hand it back in a more timely way. Some teachers wanted a few extra days on top of what was already scheduled. The advantage of this was to slow the pace of the course, to iron out the scheduling quirks, 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 is all the time they could devote. It was decided that the simplest fix was to have the course begin on a Wednesday and end on a Tuesday (not Monday to Friday) so that two weekends would be used as rest days. (In summer 2006, we wanted to schedule before July 4, and we had to avoid overlaps with other VESC courses. In future years, this will be less of a problem.)

In the planning of the 2007 course, the instructors made a list of things to be improved upon – things that popped up on course evaluations, discussions with teachers, and in the fall follow-up discussions of the year before. Many of the suggestions from 2006 were implemented. The course was spread out over three weeks, and changes were made in the sequencing of the material to make the material flow better. The instructors felt that the course was taught better the second time around. Additional podcasts were created, the block and card geologic structure lab was done (a big hit according to the evaluations) in 2007 after having been passed over in 2006, the color card summary of the Virginia geology was refined and better presented, and the extra weekend enabled the instructors to grade and return classwork more promptly. However, two additional problems arose that were not anticipated.

One of the chief complaints was that the 2 day field trip to Petersburg ended on a Friday, and due to the long driving time, we arrived back at Radford around 9 pm. Many teachers felt that they did not want to drive home for the weekend immediately after the trip. We thought long and hard about that before the course began, and it was a trade-off compared to 2006. In 2006, the trip from Williamsburg ended on the day before the last day of class. Teachers did not have to drive home immediately after the trip, but they had to take the final exam post-test the next day. In 2007, they had to drive back after the trip, but they had two days to rest with two more class days after that, with the final exam on the end of the second class day. We felt the latter situation was preferable, although it certainly wasn't ideal. The two teachers from Richmond, however, were allowed to peel off from the rest of the class in the Richmond area, so their drive home was actually very short.

The second problem was finding the right difficulty level to pitch to the class. In 2006, we found the right level – a good match for the experienced group that we had, and consistent with the course goals initially laid out by the state-wide collaborating group. In 2007, we intended to follow the successful blueprint from 2006. Previously, we alluded to the fact that the 2007 class was a younger group and these folks had different expectations. It is difficult to judge what type of class personality you are going to have before you actually meet the people and the class is well underway. However, there were some subtle clues we should have picked up on in our initial surveys during the registration period in the months before the class began. Although this was not true of all the teachers, many of the veterans from 2006 attended because of recertification requirements, but they could afford to be a bit choosy about which course to take and some could afford to wait a year or two before having to commit to a class. It was evident that they chose Geology of Virginia because they wanted to be there. It was our impression, however, that more of the 2007 people tended to be “under the gun” in terms of deadlines and wouldn’t have chosen to take the course if it wasn’t necessary. It was also our impression, during the teaching of the course, that there was a larger subset of academically weaker teachers in 2007 than in 2006, and this was born out by the grades on the post-test. There was a distinct cluster of three grades at the bottom of the class (in the 50% range) that all belonged to experienced teachers, while the inexperienced teachers had better grades. As previously discussed, pitching the course at the appropriate level is tricky for a group this diverse, and we are seeing that year-to-year variations can make a difference in the course evaluations and that what works well one year will not work the next year, even if the instructors think that the course is taught better. The data also suggests that initial experience level both in terms of geology knowledge and teaching experience is less relevant than overall academic fitness and motivation in terms of performance in the course.

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 was positively reviewed by everyone who had a chance to experience them.. Teachers felt that they are “neat”, a pleasant way to learn, and fulfilled the objective of providing background material. From the instructors’ point of view, they are fun to make, and a creative outlet although the creation process is lengthy and intense. The downside is one of technology on the teachers' side: Some teachers are not very technology oriented and appear rather clueless about anything dealing with computers, some lack broadband connections, and some teachers' only broadband connection is through their schools where they are at the mercy of their network administrators. Eventually, these obstacles will subside as people get better connections and more comfortable with technology. 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 class time people have to travel to Radford, and better serve the teachers of southwest Virginia.

The emphasis on virtual field trips for the class projects in 2007 was very positive from the instructor's point of view. In order to create them, teachers had to get outside in 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 (particularly The Breaks Interstate Park, and the Geology of Danville) were outstanding.

Conclusion

The evaluation results lead to the conclusion that the course fulfilled its stated objectives of boosting the geological knowledge of teachers, filling an 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. Teachers collected many samples and photos that they can use in the field, and have the course's materials and activities at their disposal to use in their own teaching. Teachers created projects based on the local geology of their home counties that can be used in their 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.

Geology of Virginia for Teachers
Geology 691
Summer 2006
Radford University Edition

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Textbooks: The Geologic Map of Virginia, 1993, Virginia Division of Mineral Resources, Charlottesville, Virginia
Laboratory Studies in Earth History, 8th ed., 2004, Brice, James C., Levin, Harold L., and Smith, Michael S., McGraw Hill, New York

Course Schedule:
Monday, June 19: Morning: Pre-test, Geologic Time, Relative and Absolute Dating
Afternoon: Lab activities: *Relative Dating, Fossils and Dating, Absolute Dating
Tuesday, June 20: Morning: Overview of the Geology of Virginia
Afternoon: Lab activity: *The Geologic Map of Virginia
Wednesday, June 21: Morning: Rock Interpretation
Afternoon: Field Trip: *Floyd County
Thursday, June 22: 8:30 am start – *all day trip to Mount Rogers
Friday, June 23: Morning: Blue Ridge, more Rock Review
Afternoon: Field Trip: *Price Mountain

Monday, June 26: Morning: Piedmont and the Valley and Ridge
Afternoon: Lab activity: Structural Geology
Tuesday, June 27: Morning: Plate Tectonics
Afternoon: Field Trip: *Valley and Ridge Stratigraphic Section
Wednesday and Thursday, June 28 and 29
8:00 am start - *Field Trip to the Blue Ridge, Piedmont, and Coastal Plain, Williamsburg
Friday, June 30: Morning: Mesozoic Basins and the Cenozoic of Virginia
Afternoon: Lab Activity: The Big Picture, *Post-test

Saturday Fall Follow-up Session: September 16

Final Project: Teachers will develop a geology activity based on the geology of their home county appropriate for their class.

Evaluation:

Relative Dating	10 pts
Geologic Map of Virginia	20 pts
Floyd County trip	10 pts
Mount Rogers trip	20 pts
Price Mountain trip	10 pts
Valley and Ridge trip	10 pts
Williamsburg trip	30 pts
Post Test	20 pts
Project	40 pts
Total	170 pts

Grading Scale:

>153 pts	A
136-153	B
119-136	C
102-119	D
<102	F

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Textbook: The Geologic Map of Virginia, 1993, Virginia Division of Mineral Resources, Charlottesville, Virginia
Shaded Relief Map of Virginia, 1:500,000 scale, 1973, U.S. Geological Survey

Course Schedule:
Wednesday July 11: Morning: Pre-test, Geologic Time, Relative and Absolute Dating
Afternoon: Lab activities: *Relative Dating, Fossils and Dating
Thursday, July 12: Morning: Rock interpretation, Rock ID lab
Afternoon: *Floyd County trip
Friday, July 13: Morning: Geology of Virginia Overview, Blue Ridge
Afternoon: Lab Activity: Geologic Map of Virginia lab, part 1

Monday, July 16: 8:30 am start – *Mount Rogers trip (all day)
Tuesday July 17: Morning: The Piedmont and Mesozoic Basins
Afternoon: Lab Activity: *Geologic Map of Virginia lab, part 2; Cards and Blocks lab
Wednesday, July 18: Morning: The Valley and Ridge, Appalachian Plateau
Afternoon: *Valley and Ridge (Giles County) trip
Thursday and Friday, July 19 and 20: 8:00 am start – *Blue Ridge, Piedmont, Coastal Plain trip

Monday, July 23: Morning: Field Trip Review, The Coastal Plain
Afternoon: *Price Mountain trip
Tuesday, July 24: Morning: Plate Tectonics and the Big Picture
Afternoon: *Post-test

Saturday Fall Follow-up Session: date TBA

Final Project: Teachers will develop a geology activity based on the geology of their home county appropriate for their class.

Course Goals:

1. Identify common rocks and explain their origin in terms of the rock cycle, concentrating on major sediment and rock types in Virginia.
2. Describe the distribution, origin, and economic and environmental importance of renewable and nonrenewable resources in Virginia. (ES 6abc, ES 7)
3. 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.
4. 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)
5. Synthesize the sequence of geologic events from geologic maps, cross-sections, and/or outcrops applying information from both relative and absolute dating methods.
6. 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)
7. 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, read topographic and geologic maps).
8. Develop and implement inquiry-based lessons that reflect an increased capacity to engage and stimulate students in a confident and reflexive manner.

Evaluation:

Relative Dating	10 pts
Geologic Map of Virginia	20 pts
Floyd County trip	10 pts
Mount Rogers trip	20 pts
Price Mountain trip	10 pts
Valley and Ridge trip	10 pts
2-Day trip	10 pts
Post Test	20 pts
Project	40 pts
Total	150 pts

Grading Scale:

>135 pts	A
120-135	B
105-120	C
90-105	D
<90	F