# KÉYAH MATH, PLACE-BASED, CULTURALLY-RESPONSIVE, TECHNOLOGY-INTENSIVE, QUANTITATIVE MODULES FOR INTRODUCTORY UNDERGRADUATE GEOSCIENCE

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## Introduction

Kéyah Math, is a project that developed a series of versatile, place-based, culturally-responsive, and technology-intensive modules in mathematical geoscience to enhance undergraduate geoscience courses, particularly for Native American students. The name, *Kéyah*, the Diné (Navajo) term for their home lands and the environment, emphasizes this connection.

Fourteen modules address five levels of mathematical content and are partitioned among seven topics. (Note that one of these modules is a demonstration of the Kéyah Math format and is considered Level 0.) Kéyah Math Modules contain exercises that typically are not found in introductory geoscience textbooks. Nor are they readily available commercially in ancillary materials. These *place-based* and *culturally-responsive* modules draw on data-rich examples from the geology and environs of the Native American lands and adjoining regions of the Southwest United States. They incorporate Native ideas and knowledge about Earth materials, processes, features, and history; including Indigenous terminology wherever possible. In addition, the modules address topics and issues of interest to Native American and other minority communities in the region. The versatility of and easy access to the modules, via the World-wide-web, will enable any number of them to be integrated into any basic course, regardless of the textbook, laboratory manual, or grade-level. The specific modules and their mathematical levels are given in the tables below. Table 1 provides an organization of the modules themselves, while Table 2 shows the requisite mathematics per level.

Table 1. Organization of Kéyah Math Modules

| Topic | Mathematical Level | Module Name |
|---|---|---|
| **Demonstration of Kéyah Format** | Level 0 | Age of the Universe |
| **Stream Flow** | Level 1 | Stream Flow for the Animus River |
| | Level 2 | Snow Melt & Stream Flow for the Animus River |
| **Earthquakes** | Level 2 | Location of the Epicenter of an Earthquake |
| **Volcanic Processes** | Level 2 | Sunset Crater |
| **Age of the Earth** | Level $2^+$ | Age of the Earth |
| | Level 4 | Age of the Earth |
| **Impact Processes** | Level 2 | Meteor Crater |
| | Level 4 | Meteor Crater |
| **How Big is Earth** | Level 2 | The Size of the Earth |
| | | The Size of the Earth, Estimated in Arizona |
| | Level 3 | Mass & Density of the Earth |
| | | Size, Mass, & Density of the Earth |
| **Layers of the Earth** | Level 3 | Layers of the Earth |

Table 2. Requisite Mathematics per Level

| Level | Mathematical Topics |
|---|---|
| Level 1 | Pre-Algebra, Substitution into Formulas, Computation, Simple Geometry |
| Level 2 | Algebra with Equations (not Functions), Solving Equations, Reading Graphs, Geometry |
| Level 3 | Algebra with Functions, Evaluating Algebraic Functions, Solving Equations, Graphing |
| Level 4 | Pre-Calculus, Algebraic & Exponential Functions, Evaluation, Graphing, Geometry |

To determine the success of Kéyah Math the goal of this evaluation is to assess the extent to which the Project Investigators, (PI's), met their stated objectives. To this end, the evaluator will focus on the following questions which are directly tied to the project objectives:

1. To what does Kéyah Math bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data?
2. To what extent does Kéyah Math attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities and contemporary issues of significance to their communities?
3. To what extent does Kéyah Math improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences?
4. Does Kéyah Math enhance the global infrastructure for geoscience education through universal web-based dissemination, and linkage to major digital clearinghouses such as the Digital Library for Earth System Education (DLESE)?

## Evaluation Plan

The stated objected objectives are multi-faceted and include goals for the written materials, the dissemination/implementation of the materials, and students who will use the materials. Therefore, this evaluation addresses these three components: 1) The modules themselves; 2) Instructors who implement the modules with their own students; and 3) Students who have participated in the implementation. These components comprise the three stages of the evaluation.

### Stage One

During Stage One the evaluator determined the extent to which the modules reflect the first three objectives, using the Modules Assessment Inventory which was created by the evaluator. This 28 item survey was given to participant/instructors who attended a PI-directed workshop and worked through, at least, one module to measure the extent to which the modules met the stated criteria of the PI's. This instrument, located in Appendix A, was given to instructors before and after the PIs made the final revisions of the modules for classroom use.

Stage Two

Project Objectives 1 and 3 use language that dictates a need to show student improvement. Therefore, the materials need to be used with students in *real* classrooms. Several instructors indicated a desire to implement one, or more, of these modules with their students. Therefore, during stage two, the evaluator monitored these implementations via telephone. These telephone interviews occurred prior to the beginning of the implementation and after the it was completed. Discrete interview protocols were developed to guide the interview and ensure consistency. These are included in Appendix B.

To determine whether or not Objective 4, which addresses dissemination via the World Wide Wed, has been met, the evaluator will assess the quality of the web-site. This did not entail an interview, therefore another protocol was not needed.

Stage Three

Objective 3 asserts that the modules will be of interest to students, Native American students in particular, due to the use of *real* data and case studies taken from familiar, culturally-significant localities and contemporary issues of significance to their communities. It was hoped that some of the students who studied the modules might be interviewed to determine the extent to which this objective is achieved. Because of legal considerations and student schedules, this was not possible. Hence, the evaluator assessed this objective through the eyes of the instructors who taught the modules.

## Instrument Development

Module Assessment Inventory (MAI)

The purpose of this instrument is to determine the extent to which the modules reflect the first three objectives. It uses a Likert Scale and is based on the specific ideas listed below that are closely related to the project objectives and is provided in Appendix A. The MAI posits that the modules will

1. Bolster the interest and capabilities of students in the geosciences through the use of scientific inquiry and current scientific data;
2. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities;
3. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers;
4. Incorporate Native knowledge of Earth's processes and history, using Indigenous terminology; and that
5. The organization of the modules includes the following components: The Text, Review Topics, The Journal, and The Tool Chest.

### Instructor Telephone Interview Protocols

Prior to and after the implementation the evaluator monitored the instructor's thinking about the module itself and the assessment of the progress of the class, their activities, etc. To facilitate the length of the interviews themselves, as well as ensuring that the reliability was maintained, each interview addressed questions that were developed on interview protocols. The Interview Protocols are included in Appendix B.

## Results

### The Modules Assessment Inventory (MAI)

Each item of the MAI was scored using a scale of 1 to 5, with 5 being the most positive response. To determine whether a response was positive, negative, or ambivalent, the evaluator used the following scale:

$1 \leq n < 2.5$ , *Negative*

$2.5 \leq n < 3.5$, *Ambivalent*

$3.5 \leq n \leq 5$, *Positive*

The MAI was administered before and after the modules had been revised and/or up-dated using feedback from participants at various workshops that the PIs gave during the project. (Note that the purpose of the workshops was for Evaluation and Dissemination. Specifically the modules were reviewed, as per the participant's choice, and they were adapted to particular State Standards. This adaptation made possible the Modules availability for use in secondary schools.)

The results of these analyses for specific modules are given below in Table 3 which also indicates whether or nor each module has been implemented. The evaluator rated each module that was not chosen for participant review after the revision process. Specific numerical results for each module *before* revisions are given in Appendix C; the results *after* the revisions are in Appendix D.

Table 3. Ratings of Specific Modules, Before- and After-Revisions

| Module | Before Revision | After Revision | | Implemented |
| --- | --- | --- | --- | --- |
| | | Participant | Evaluator | |
| Age of the Universe | | | Positive | Yes |
| Stream Flow for the Animus River | Ambivalent | Positive | | Yes |
| Snow Melt & Stream Flow for the Animus River | | Positive | | Yes |
| Location of the Epicenter of an Earthquake | Ambivalent | Positive | | Yes |
| Sunset Crater | | | Positive | Yes |
| Age of the Earth, Level 2+ | | | Positive | |
| Age of the Earth, Level 4 | | | Positive | |
| Meteor Crater, Level 2 | Ambivalent | | Positive | Yes |
| Meteor Crater, Level 4 | | | Positive | |
| The Size of the Earth | Positive | Positive | | Yes |
| The Size of the Earth, Estimated in Arizona | | | Positive | Yes |
| Mass & Density of the Earth | | Positive | | |
| Size, Mass, & Density of the Earth | | | Positive | |
| Layers of the Earth | Positive | | Positive | |

The initial results, provided by the participants suggested that some specific modules needed revising. Accordingly, the PIs attended very carefully to the comments of participants and modified each module and applied the same criteria to modify the remaining ones as well. As is shown in Table 3, after the revisions, and in every case, all of the modules were judged to be positive.

Generally speaking, these results are very positive. As shown in the specific numerical findings given in Appendix C, some of the specific items *before* the revisions were rated Negative even though none of the aggregates were Negative. However, *after* the revisions (see Appendix D), not one of the specific items was rated negative. Therefore, these results are overwhelmingly positive.

A closer examinations of those specific items on the MAI, discloses that there were seven in which the aggregate of scores was less than '3', Not Sure. Hence, these items were less than positive. Table 4, below, organizes this information and determines the differences between the items before and after the revisions.

Table 4. Comparison of Most Negative Items: Before & After Revisions

| Item | Objective | Before Revisions | After Revisions | Net Change |
|---|---|---|---|---|
| 11. The questions posed in this module encourage the use of scientific inquiry. | A | 2.5 | 4.3 | 1.8, Gain |
| 15. Examples used in this module feature the geology and/or environs of Native American lands. | B | 2.7 | 4.3 | 1.6, Gain |
| 8. These activities include Native knowledge of Earth's processes. | D | 2.4 | 4.3 | 1.9, Gain |
| 9. This material features Native knowledge of Earth's history. | D | 3.3 | 2.8 | 0.5, Loss |
| 16. The language contained in this module is rich with Indigenous terminology. | D | 1.8 | 2.6 | 0.8, Gain |
| 19. The Experimentation Applet(s) given for this module is(are) confusing. | E | 2.9 | 3.1 | 0.2, Gain |
| 27. There are not enough review topics included in this module for introductory undergraduate geoscience students. | E | 2.3 | 3.7 | 1.4, Gain |

After perusing Table 4 one notes that all, except one, of the items had positive gains after the revisions and one-half of the items increased from ambivalent to positive ratings. These are favorable results. However, most of the items created for Objective D were less than positive at some point. One might determine that the items should be revised or, perhaps, the participants were unfamiliar with the language. The worst possible scenario would suggest that the modules might be further revised to reflect Native knowledge of Earth's processes, history, and materials; and that they might contain more Indigenous terminology. On the other hand, given the gains seen in the items from Objective E, Module Organization, it appears that the PIs made a considerable effort to include more explanations for the Experimentation Applets and increase the review topics.

The sizeable gains in the items from the objectives given in Table 4 also point to major improvements from the revisions. Generally speaking, the average gain score is

1.03 which is highly significant ($\rho < .0001$). (Note that before revisions, mean = 2.6; after revisions, mean = 3.6.) Clearly, the PIs listened carefully to the participants and revised accordingly.

Following this analysis of the MAI by module, the MAI was partitioned into categories based on the Project Objectives that were identified by the PIs in the original proposal. In particular, these categories address either one of the goals and objectives of the study or the organization of the modules themselves. Note that 25% of the items were reversed, so that the most positive response was Strongly Disagree. These particular items are designated with an R after the number, e.g. 28R.

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data.

   6, 11, 13, 22, 23, 28R

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities.

   2, 4, 14, 15, 18, 21

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences.

   25

D. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology.

   7R, 8, 9, 16

E. Module Organization:

   Part 1: The Text
   1, 3, 17R

   Part 2: Review Topics
   5, 12 R, 26R, 27R

   Part 3: The Journal
   20

   Part 4: The Tool Chest
   10, 19R, 24R

After the scores for each item on the specific instruments were averaged and these averages were partitioned given the partitioning as shown above. In addition, using the aggregate of scores for each item and the above scale, the evaluator ranked each partition which pertained to one of the original project objectives, before and after the revisions as *Positive, Negative,* or *Ambivalent.* (Note that the evaluator eliminated any data point that was considered an outlier for any given item. In other words, the data point was at least 1.5 points below the next lowest one.) These results are shown in Table 5 below.

Table 5. Comparison of Ratings of Project Objectives:
Before and After Revisions

| Objective | Before Revision | After Revision |
|---|---|---|
| A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. | Ambivalent | Positive |
| B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. | Ambivalent | Positive |
| C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. | Positive | Positive |
| D. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. | Ambivalent | Ambivalent |
| E. Module Organization | Ambivalent | Positive |

<u>Classroom Implementation</u>

Several modules of the Kéyah Math Project were implemented during the time of the project itself. Of these, five instructors who had participated in at least two workshops were chosen to provide a closer look at the particular use, reactions, and achievements of specific modules in *real* classrooms. The Evaluator interviewed each of these instructors, using the Instructor Interview Protocols, located in Appendix B, both before and after the testing period. Results of the particular interviews of the five individuals were summarized, using fictitious names. The individual summaries may be found in Appendix F.

Of the five instructors in the southwestern United States, three are geologists (two in undergraduate institutions and one in high school), one is a mathematics instructor at a college, and one is a school teacher of $6^{th}$ grade gifted students. The undergraduate courses were designed for entry-level science or mathematics students and the high school course was $9^{th}$ grade physical science.

Most of the modules were used as in-class activities varying in length from two days to a full week. Only one instructor used the module as an out of class assignment. Three of the implementations occurred in computer labs. For these classes the module was used directly on the web site. In the other two classes, one had no computers and one had one computer with a projector. These situations required that the instructors provide students with handouts: one was copied straight from the web site; the other had been modified slightly. It is included in Arlene's Summary, Appendix F.

Generally speaking, the implementations of the modules went well. In the class that only had one computer, the best part was that they used Google Earth. Some other students liked the web site because it was "different from the text." That instructor loved the positive reactions of the students: "Wow!' etc. In one situation there were a high number of students "who could understand the problem and the results." And, for two groups of students, they liked "applying math to [solve a] geologic problem." Even when the students did not seem to know exactly what to do, most of the students jumped right in and got to work.

The most surprising thing for two of the instructors was the seemingly little awareness of scientific notation among their students. Another instructor was surprised that through the activity his students (finally) realized "that conversion is important." He was also surprised at the number of students who could not "even get started" and the amount of class time that is needed for an activity as involved as these modules.

Finally, one group of students did not seem “to understand that you can determine mass or energy using the same formula.”

For many instructors, the worst part of the implementation was also the most surprising part. However, in one situation the students wanted the module to contain more pictures and larger font. Another instructor believes that her module was lacking because it had no digital component. The next time she teaches the unit she will use the Stromboli link first, and then use the module to allow the students to see the geology from a mathematical point of view. It is interesting that most of the negatives are really positive.

Across the board, the students were successful in acquiring the knowledge and understanding for which the modules were designed. To ensure that this knowledge was based on the module and not information that the students had prior to its use, the instructors established base lines for their students applying a variety of methods, both formal and informal. These ranged from brainstorming and using pretest type questions on class warm-ups to actual pretest surveys using Likert style ratings. In all cases the instructors were more than satisfied with the success of their students on the assessment of the module, typically a written test.

Approximately 25% of the students who participated in the implementation of these modules are Native American. There was virtually no difference in their success rate and that of the remaining students. All of the instructors were very pleased with the knowledge and understanding that their students gained using the Kéyah Math Modules.

## Concluding Remarks

The goal of this evaluation was to assess the extent to which the Project Investigators, PI’s, meet their stated objectives. Answers to each of the initial four questions will be discussed in this section, beginning with Question 2 then going back to Questions 1, 3, and 4.

<u>Question 2</u>. To what extent does Kéyah Math attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities and contemporary issues of significance to their communities?

To answer this question we draw on information from the modules themselves. Recall that the Modules Assessment Instrument (MAI) contains several items that attend to various components of the project's objectives and the organization of the modules themselves. Specifically, the six items that address this question, Part B were rated Positive after the major revision. Part D, with four items, also addressed this particular question. The reviewers apparently were ambivalent about the use of *case studies taken from familiar, culturally-significant localities and contemporary issues of significance to their communities.* Most of the items created for Objective D were less than positive at some point. One might determine that the items should be revised or, perhaps, the participants were unfamiliar with the language. The worst possible scenario would suggest that the modules might be further revised to reflect Native knowledge of Earth's processes, history, and materials; and that they might contain more Indigenous terminology. However, note that the aggregate of the items for Objective D and Objective B is extremely positive (7 @ Positive, and 3 @ Ambivalent). Clearly the PIs made an attempt to emphasize issues and language that would attract the interest of Native American students. Interestingly, this was very appealing to non-Native American students, as well.

<u>Question 1</u>. To what extent does Kéyah Math bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data?

The results of the MAI, Part A, address the use of scientific inquiry and current scientific data in the modules. Consequently, we conclude that Kéyah Math does a fine job in presenting problems that draw on current scientific data and assume the use of scientific inquiry. Regarding the extent to which the modules bolster the capabilities of the students, we look at the results of the instructor interviews. They were very pleased with the progress of their students and the students' enthusiasm for the material itself.

In fact one group of students exclaimed that the module was *better than utube … and myspace*! This is high praise, indeed!

Question 3. To what extent does Kéyah Math improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences?

All of the students who participated in this evaluation are at an early stage in their undergraduate programs. In fact, they were either in entry-level courses for non-science majors or in secondary schools. However, the answer to this question demands that students using the modules must show growth in their knowledge of the particular unit. Hence the instructors established base lines for their students applying a variety of methods, both formal and informal. These ranged from brainstorming and using pretest type questions on class warm-ups to actual pretest surveys using Likert style ratings. In all cases the instructors were more than satisfied with the success of their students on the assessment of the module, typically a written test. The enthusiasm generated by their participation was even more gratifying.

Approximately 25% of the students who participated in the implementation of these modules are Native American. There was virtually no difference in their success rate and that of the remaining students. This is a particularly impressive, but not surprising, result. After all, good curriculum is good for students, and activities that are student-centered are exceptionally good for Native American and other minority students, i.e. students who generally have not been successful in mathematics and the other sciences. It is very nice to have quality alternative units for undergraduate geoscience and mathematics courses, especially those that are also appropriate for secondary school students.

Objective 4. To what extent does Kéyah Math enhance the global infrastructure for geoscience education through universal web-based dissemination, and linkage to major digital clearinghouses such as the Digital Library for Earth System Education (DLESE)?

As mentioned previously in this report, the Kéyah Math modules are part of a web site, http://keyah.asu.edu. The materials used by most of the students who participated in this evaluation were accessed via this web site. At the time of this writing the site was not linked to the Digital Library for Earth System Education, www.dlese.org. However, one of the PIs does have a collection of *3D flyover movies* that depicts geologically interesting localities in the Southwest United States. The selection includes well-known landmarks such as Meteor Crater, Monument Valley, Hopi Buttes, and others. They are available in a number of different formats and file sizes. The movies, the data files used to make them, and the software to view them are all available for free download. Another web site that might prove attractive for disseminating these materials is http://serc.carleton.edu/quantskills .

## Final Remarks

In summary, the PIs are to be commended for attending to their intended objectives as precisely as they have. Moreover, the quality of the modules themselves which are *place-based* and *culturally-responsive* that draw on data-rich examples from the geology and environs of the Native American lands and adjoining regions of the Southwest United States is noteworthy. Their attention to increasing the dearth of materials that include quantitative exercises in entry-level geoscience courses is highly praiseworthy. As shown in the concluding remarks given by C.A. Manduca, E. Baer, G. Hancock et al, in a recent article in *EOS* (Vol.89, No.16, April 2008, p.150)

> Geoscience is quantitative. For many of us, the excitement of applying quantitative techniques to understanding aspects of the Earth system was a major motivation for entering the geosciences. Bringing quantitative approaches into our teaching is an opportunity to share that excitement and to raise awareness of the power our science brings to addressing many of the major societal issues of our time. You can begin today by infusing just one more quantitative activity into your course . . .

## Appendix A

## ***Kéyah Math*** **Modules Assessment Inventory**

Module Name:

Using the scale provided, please rate each of the following statements.

| | Statement | Strongly Disagree | Disagree | Not Sure | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| 1. | The problem to be investigated is well-formulated. | SD | D | NS | A | SA |
| 2. | The problem addresses a topic and/or issue that would interest to (your) Native American students. | SD | D | NS | A | SA |
| 3. | The field trip(s) suggested for the problem are appropriate. | SD | D | NS | A | SA |
| 4. | The activities associated with this module incorporate Native ideas. | SD | D | NS | A | SA |
| 5. | The review topics included in this module are appropriate for introductory geoscience students. | SD | D | NS | A | SA |
| 6. | I believe that this material will strengthen the capabilities of introductory undergraduate geoscience students. | SD | D | NS | A | SA |
| 7. | These activities presume Native knowledge of Earth's materials. | SD | D | NS | A | SA |
| 8. | The activities include Native knowledge of Earth's processes. | SD | D | NS | A | SA |
| 9. | This material feature Native knowledge of Earth's history. | SD | D | NS | A | SA |
| 10. | The Computation Applets provided in this module are. easy to use | SD | D | NS | A | SA |
| 11. | The questions posed in this module encourage the use of scientific inquiry. | SD | D | NS | A | SA |
| 12. | There is not enough information in the link(s) to math concepts that is provided in this module. | SD | D | NS | A | SA |
| 13. | This module contains current scientific data. | SD | D | NS | A | SA |
| 14. | The data and/or case study is taken from familiar or culturally-significant localities. | SD | D | NS | A | SA |
| 15. | Examples used in this module feature the geology and/or environment of Native American lands. | SD | D. | NS | A | SA |
| 16. | The language contained in this module is rich with Indigenous terminology. | SD | D | NS | A | SA |
| 17. | The link(s) contained in this module to relevant information is not appropriate for introductory geoscience students. | SD | D | NS | A | SA |
| 18. | I believe that the material in this module is relevant to Native American students lives and/or communities. | SD | D | NS | A | SA |
| 19. | The Experimentation Applet(s) given for this module is(are) confusing. | SD | D | NS | A | SA |

| | | | | | |
|---|---|---|---|---|---|
| 20. I like having *The Journal* to be an integral part of the module. | SD | D | NS | A | SA |
| 21. The geology concept(s) integrated into this module are typically found in traditional introductory geoscience texts. | SD | D | NS | A | SA |
| 22. I believe that this material will bolster the interest of all undergraduate geoscience students. | SD | D | NS | A | SA |
| 23. These materials are appropriate for use in any introductory undergraduate geoscience course, regardless of the textbook or laboratory manual. | SD | D | NS | A | SA |
| 24. The Instruction Applet(s) supplied with this module are too esoteric for (my) introductory geoscience students | SD | D | NS | A | SA |
| 25. I believe that this module will enhance the quantitative skills Native American students. | SD | D | NS | A | SA |
| 26. The link(s) to geology concepts do not contain enough information for (my) typical introductory geoscience student. | SD | D | NS | A | SA |
| 27. There are not enough review topics included in this module for introductory undergraduate geoscience students. | SD | D | NS | A | SA |
| 28. I would not recommend this module for use with introductory geoscience students. | SD | D | NS | A | SA |

29. What contemporary issue in geoscience drives the mathematics in this module?

30. What basic quantitative skills are supported and/or developed in this module?

## Appendix B

### Instructor Telephone Interview, Pre-Implementation

Module ____________________________ Name _____________________________

Course/Grade Level ________________ Date _________ Location ____________

Dates of Implementation _____________

1. Why have you chosen this unit?

2. Course Objectives / State Standards? Which ones?

3. Have you chosen your assessment instruments? Explain

4. How have/will you ensure that the information in the module will be 'new' to your students?

5. Do you plan any special activities for your students in this module?

6. Will you attend the February meeting?

**Instructor Telephone Interview: Post-Implementation**

Module__________________________ Name____________________________

Course/Grade Level_______________ Date__________ Location___________

Dates of Implementation____________

1. Generally speaking, how did it go?

   The best part(s)? The worst part(s)? Any surprises?

   Did you have to make modifications to the module? Explain.

2. What was the reaction of the students?

   What did they seem to like best?

3. Did the students accomplish the objectives you had for the module?
   How do you know?

4. If you were to teach this module again, what changes, if any, would you make?

5. Is it possible for me to interview any of your students? If so, who? (Name & Telephone Number)

## APPENDIX C

### Pre-Revision Results: Modules Assessment Inventory

**Earthquakes, Ambivalent Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. **A** (Avg = 2.83)

| | | |
|---|---|---|
| 6. 3 | 13. 1.5 | 23. 4 |
| 11. 1 | 22. 4 | 28R. 3.5 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. **A** (Avg = 2.67)

| | | |
|---|---|---|
| 2. 3 | 14. 1 | 18. 4 |
| 4. 2 | 15. 1 | 21. 5 |

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **P**

25. 4

D. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **N** (Avg = 1.25)

| | | |
|---|---|---|
| 7R.4 | 9. 1 | 16. 1 |
| 8. 1 | | |

E. Module Organization **A** (Avg = 3.3)

Part 1: The Text **A** (Avg = 3.67)

| | | |
|---|---|---|
| 1. 3 | 3. 3 | 17R. 5 |

Part 2: Review Topics **A** (Avg = 3.13)

| | | |
|---|---|---|
| 5. 4 | 26R. 2.5 | 27R. 2.5 |
| 12 R. 3.5 | | |

Part 3: The Journal **A**

20. 3

Part 4: The Tool Chest **A** (Avg = 3.5)

| | | |
|---|---|---|
| 10. 4.5 | 19R. 3 | 24R. 3 |

**How Big is Earth? Positive Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. **P** (Avg = 3.58)

| | | |
|---|---|---|
| 6. 3 | 13. 4 | 23. 3.5 |
| 11. 4 | 22. 3 | 28R. 4 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. **P** (Avg = 3.5)

| | | |
|---|---|---|
| 2. 4.5 | 14. 4 | 18. 2 |
| 4. 3 | 15. 4.5 | 21. 2 |

E. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **P**

25. 4

F. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **A** (Avg = 2.75)

| | | |
|---|---|---|
| 7R 3 | 9. 3 | 16. 2 |
| 8. 3 | | |

E. Module Organization **A** (Avg = 2.77)

Part 1: The Text **A** (Avg = 2.67)

| | | |
|---|---|---|
| 1. 2 | 3. 3 | 17R. 3 |

Part 2: Review Topics **A** (Avg = 2.75)

| | | |
|---|---|---|
| 5. 3 | 26R. 3 | 27R. 2.5 |
| 12 R. 3 | | |

Part 3: The Journal **A**

20. 3

Part 4: The Tool Chest **A** (Avg = 2.67)

| | | |
|---|---|---|
| 10. 2 | 19R. 3 | 24R. 3 |

**Layers of Earth? Positive Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. **P** (Avg = 4.25)

| | | |
|---|---|---|
| 6. 4 | 13. 4 | 23. 4 |
| 11. 4 | 22. 4 | 28R. 5 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. **P** (Avg = 3.67)

| | | |
|---|---|---|
| 2. 4 | 14. 3 | 18. 4 |
| 4. 3 | 15. 3 | 21. 5 |

G. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **P**

25. 4

H. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **A** (Avg = 3.67)

| | | |
|---|---|---|
| 7R 3 | 9. 3 | 16. 2 |
| 8. 3 | | |

E. Module Organization **A** (Avg = 3.0)

Part 1: The Text **A** (Avg = 3.67)

| | | |
|---|---|---|
| 1. 4 | 3. 3 | 17R. 4 |

Part 2: Review Topics **A** (Avg = 2.25)

| | | |
|---|---|---|
| 5. 2 | 26R. 2 | 27R. 2 |
| 12 R. 3 | | |

Part 3: The Journal **A**

20. 3

Part 4: The Tool Chest **A** (Avg = 3)

| | | |
|---|---|---|
| 10. 3 | 19R. 3 | 24R. 3 |

**Meteor Crater, Ambivalent Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. **A** (Avg = 2.33)

| | | |
|---|---|---|
| 6. 3 | 13. 4 | 23. 2 |
| 11. 1 | 22. 2 | 28R. 2 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. **P** (Avg = 3.5)

| | | |
|---|---|---|
| 2. 3 | 14. 5 | 18. 3 |
| 4. 4 | 15. 3 | 21. 3 |

I. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **A**

25. 3

J. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **A** (Avg = 2.5)

| | | |
|---|---|---|
| 7R. 2 | 9. 4 | 16. 2 |
| 8. 2 | | |

E. Module Organization **A** (Avg = 3.3)

Part 1: The Text **A** (Avg = 3.67)

| | | |
|---|---|---|
| 1. 3 | 3. 4 | 17R. 4 |

Part 2: Review Topics **A** (Avg = 3)

| | | |
|---|---|---|
| 5. 4 | 26R. 3 | 27R. 3 |
| 12 R. 3 | | |

Part 3: The Journal **A**

20. 3

Part 4: The Tool Chest **A** (Avg = 2.33)

| | | |
|---|---|---|
| 10. 2 | 19R. 2 | 24R. 3 |

**Streamflow, Ambivalent Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. **A** (Avg = 2.83)

| | | |
|---|---|---|
| 6. 3.5 | 13. 1.5 | 23. 3.5 |
| 11. 2.5 | 22. 3 | 28R. 3 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. **A** (Avg = 3.08)

| | | |
|---|---|---|
| 2. 4 | 14. 2 | 18. 4 |
| 4. 3 | 15. 2 | 21. 3.5 |

K. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **P**

25. 4

L. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **A** (Avg = 2.75)

| | | |
|---|---|---|
| 7R 3 | 9. 3 | 16. 2 |
| 8. 3 | | |

E. Module Organization **A** (Avg = 3.43)

Part 1: The Text **A** (Avg = 4.17)

| | | |
|---|---|---|
| 1. 4 | 3. 5 | 17R. 3.5 |

Part 2: Review Topics **A** (Avg = 3.25)

| | | |
|---|---|---|
| 5. 3.5 | 26R. 3 | 27R. 2.5 |
| 12 R. 4 | | |

Part 3: The Journal **A**

20. 3

Part 4: The Tool Chest **A** (Avg = 3.33)

| | | |
|---|---|---|
| 10. 4 | 19R. 3 | 24R. 3 |

## APPENDIX D

## Post-Revisions Results: Modules Assessment Inventory

### Stream Flow, Level 2: Positive Results

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. (Avg = 4.83)

| | | | | | |
|---|---|---|---|---|---|
| 6. | 5 | 13. | 5 | 23. | 5 |
| 11. | 5 | 22. | 5 | 28R. | 4 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. (Avg = 5)

| | | | | | |
|---|---|---|---|---|---|
| 2. | 5 | 14. | 5 | 18. | 5 |
| 4. | 5 | 15. | 5 | 21. | 5 |

M. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences.

25. 5

N. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. (Avg = 3.5)

| | | | | | |
|---|---|---|---|---|---|
| 7R. | 3 | 9. | 3 | 16. | 3 |
| 8. | 5 | | | | |

E. Module Organization (Avg = 3.81)

Part 1: The Text

| | | | | | |
|---|---|---|---|---|---|
| 1. | 5 | 3. | 3 | 17R. | 4 |

Part 2: Review Topics

| | | | | | |
|---|---|---|---|---|---|
| 5. | 5 | 26R. | 4 | 27R. | 4 |
| 12 R. | 4 | | | | |

Part 3: The Journal

20. 3

Part 4: The Tool Chest

| | | | | | |
|---|---|---|---|---|---|
| 10. | 4 | 19R. | 3 | 24R. | 3 |

**Mass & Density of the Earth: Positive Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. (Avg = 3.8)

| | | | | | |
|---|---|---|---|---|---|
| 6. | 4 | 13. | 5 | 23. | 4 |
| 11. | 4 | 22. | 4 | 28R. | 2 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. (Avg = 3.5)

| | | | | | |
|---|---|---|---|---|---|
| 2. | 3 | 14. | 4 | 18. | 4 |
| 4. | 3 | 15. | 3 | 21. | 4 |

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences.

25. 4

D. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. (Avg = 3)

| | | | | | |
|---|---|---|---|---|---|
| 7R. | 3 | 9. | 3 | 16. | 3 |
| 8. | 3 | | | | |

E. Module Organization (Avg = 3.82)

Part 1: The Text

| | | | | | |
|---|---|---|---|---|---|
| 1. | 4 | 3. | 3 | 17R. | 5 |

Part 2: Review Topics

| | | | | | |
|---|---|---|---|---|---|
| 5. | 4 | 26R. | 5 | 27R. | 4 |
| 12 R. | 3 | | | | |

Part 3: The Journal

20. 3

Part 4: The Tool Chest

| | | | | | |
|---|---|---|---|---|---|
| 10. | 5 | 19R. | 3 | 24R. | 3 |

**Stream Flow, Level 1: Positive Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. (Avg = 4.3)

| | | | | | |
|---|---|---|---|---|---|
| 6. | 4 | 13. | 4.7 | 23. | 4 |
| 11. | 4.3 | 22. | 4.3 | 28R. | 4.3 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. (Avg = 4.1)

| | | | | | |
|---|---|---|---|---|---|
| 2. | 4.2 | 14. | 4.7 | 18. | 4 |
| 4. | 3.7 | 15. | 4.7 | 21. | 3.3 |

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences.

25. 4.3

D. Incororporates Native knowledge of Earth's processes and history, using Indigenous terminology. (Avg = 3.3)

| | | | | | |
|---|---|---|---|---|---|
| 7R. | 3 | 9. | 3 | 16. | 2.7 |
| 8. | 4.3 | | | | |

E. Module Organization (Avg = 3.62)

Part 1: The Text

| | | | | | |
|---|---|---|---|---|---|
| 1. | 4.3 | 3. | 3 | 17R. | 3.7 |

Part 2: Review Topics

| | | | | | |
|---|---|---|---|---|---|
| 5. | 4 | 26R. | 3.7 | 27R. | 3.7 |
| 12 R. | 3.7 | | | | |

Part 3: The Journal

20. 3

Part 4: The Tool Chest

| | | | | | |
|---|---|---|---|---|---|
| 10. | 3.7 | 19R. | 3.3 | 24R. | 3.7 |

**Epicenter of an Earthquake: Positive Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. (Avg = 3.7)

| | | | | | |
|---|---|---|---|---|---|
| 6. | 4 | 13. | 4.3 | 23. | 3.3 |
| 11. | 3.3 | 22. | 3.67 | 28R. | 3.67 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. (Avg = 3.6)

| | | | | | |
|---|---|---|---|---|---|
| 2. | 3 | 14. | 3.3 | 18. | 3.67 |
| 4. | 3 | 15. | 4 | 21. | 4.7 |

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences.

25. 3.7

D. Incororporates Native knowledge of Earth's processes and history, using Indigenous terminology. (Avg = 2.1)

| | | | | | |
|---|---|---|---|---|---|
| 7R. | 3.6 | 9. | 2 | 16. | 1.3 |
| 8. | 2.67 | | | | |

E. Module Organization (Avg = 3.42)

Part 1: The Text

| | | | | | |
|---|---|---|---|---|---|
| 1. | 3.7 | 3. | 3 | 17R. | 3.3 |

Part 2: Review Topics

| | | | | | |
|---|---|---|---|---|---|
| 5. | 4.3 | 26R. | 3.3 | 27R. | 3 |
| 12 R. | 4 | | | | |

Part 3: The Journal

20. 3

Part 4: The Tool Chest

| | | | | | |
|---|---|---|---|---|---|
| 10. | 3.7 | 19R. | 3.3 | 24R. | 3 |

**Size of the Earth: Positive Results**

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. (Avg = 5)

| | | | | | |
|---|---|---|---|---|---|
| 6. | 5 | 13. | 5 | 23. | 5 |
| 11. | 5 | 22. | 5 | 28R. | 5 |

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. (Avg = 5)

| | | | | | |
|---|---|---|---|---|---|
| 2. | 5 | 14. | 5 | 18. | 5 |
| 4. | 5 | 15. | 5 | 21. | 5 |

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences.

25. 5

D. Incororporates Native knowledge of Earth's processes and history, using Indigenous terminology. (Avg = 3.3)

| | | | | | |
|---|---|---|---|---|---|
| 7R. | 3 | 9. | 3 | 16. | 3 |
| 8. | 5 | | | | |

E. Module Organization (Avg = 3.82)

Part 1: The Text

| | | | | | |
|---|---|---|---|---|---|
| 1. | 5 | 3. | 3 | 17R. | 4 |

Part 2: Review Topics

| | | | | | |
|---|---|---|---|---|---|
| 5. | 5 | 26R. | 4 | 27R. | 4 |
| 12 R. | 4 | | | | |

Part 3: The Journal

20. 3

Part 4: The Tool Chest

| | | | | | |
|---|---|---|---|---|---|
| 10. | 4 | 19R. | 3 | 24R. | 3 |

## Appendix E

## Pre- and Post-Revisions Results

Pre-Revision Results: Modules Assessment Inventory,

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data.

**Ambivalent** (1@P + 5@A => A)

6. **A** (3,3.5,3,4,3 => 3.3) 13. **A** (1.5,1.5,4,4,4=>3) 23. **A** (4,3.5,3.5,4,2 => 3.4)
11. **A** (1,2.5,4,4,1 => 2.5) 22. **A** (4,3,3,4,2 => 3.2) 28R. **P** (3.5,3,4,5,2 => 3.5)

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities.

**Ambivalent** (2@P + 4@A => P)

2. **P** (3,4,4.5,4,3 => 3.7) 14. **A** (1,2,4,3,5 => 3) 18. **A** (4,4,2.5,4,3 => 3.4
4. **A** (2,3,3,3,4 => 3) 15. **A** (1,2,4.5,3,3 => 2.7) 21. **P** (5,3.5,2.5,5,3=> 3.8)

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **Positive**

25. **P** (4,4,4,4,3 => 3.8)

D. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **Ambivalent** (2@A + 2@N =>2.53)

7R. **A** (4,3,3,3,4 => 3.4) 9. **A** (~~1~~,3,3,3,4 => 3.3) 16. **N** (1,2,2,2,2 => 1.8)
8. **N** (1,3,3,3,2 => 2.4)

E. Module Organization **Ambivalent**

Part 1: The Text

1. **A** (3,4,2,4,3 => 3.3) 3. **A** (3,3,3,3,4 => 3.2) 17R. **P** (5,3,4,4,3.5 => 3.9)

Part 2: Review Topics

5. **A** (4,3.5,3,2,4 => 3.3) 26R. **A** (3.3,3,2.8,3.4,3.3 => 3.2) 27R. **N** (2.5,2.5,2.5,2,2 => 2.3)
12 R. **A** (3.5,4,3,3,3 => 3.3)

Part 3: The Journal

20. **A** (3,3,3,3,3 => 3)

Part 4: The Tool Chest

10. **A** (4.5,4,2,3,2 => 3.1) 19R. **A** (3,3,3,3,2 => 2.8) 24R. **A** (3,3,3,3,3 => 3)

Post-Revision Results: Modules Assessment Inventory

A. Bolster the interest and capabilities of all students in the geosciences through the use of scientific inquiry and current scientific data. **Positive** [6@P]

6. **P** [4,4,4,5,5=>4.4] 13. **P** [4.3,5,4.7,5,5=>4.8] 23. **P** [3.3,4,4,5,5=>4.3]

11. **P** [3.3,4,4,3,5,5=>4.3] 22. **P** [3.7,4,4.3,5,5=>4.4] 28R. **P**[3.7,~~2~~,4.3,4,5=>4.3]

B. Attract the interest of Native American students in particular, through the use of data and case studies taken from familiar, culturally-significant localities. **Positive** [6@P]

2. **P** [3,3,4.3,5,5=>4.1] 14. **P** [3.3,4,4.7,5,5=>4.4] 18. **P** [3.7,4,4,5,5=>4.3]

4. **P** [3,3,3.7,5,5=>3.9] 15. **P** [4,3,4.7,5,5=>4.3] 21. **P** [4.7,4,3.3,5,5=>4.4]

C. Improve the quantitative skills of Native American and other minority science students at an early stage in their undergraduate programs, better preparing them for professional careers in the geosciences. **Positive**

25. **P** [3.7,4,4.3,5,5=>4.4]

D. Incorporates Native knowledge of Earth's processes and history, using Indigenous terminology. **Ambivalent** [3@A + 1@P]

7R. **A** [3.6,3,3,3,3=>3.2] 9. **A** [2,3,3,3,3=>2.8] 16. **A** [1.3,2.7,3,3,3=>2.6]

8. **P** [2.67,3,4.3,5,5,=>4]

E. Module Organization **Positive** [8@P + 3@A]

Part 1: The Text

1. **P** [3.7,4,4.3,5,5=>4.4] 3. **P** [3,3,3,3,3=>3] 17R. **P** [3.3,5,3.7,4,4=>4]

Part 2: Review Topics

5. **P** [4.3,4,4,5,5,=>4.5] 26R. **P** [3.3,5,3.7,4,4=>4] 27R. **P** [3,4,3.7,4,4=>3.7]

12 R. **P** [4,3,3.7,4,4=>3.7]

Part 3: The Journal

20. **A** [3,3,3,3,3=>3]

Part 4: The Tool Chest

10. **P** [3.7,5,3.7,4,4=>4] 19R. **A** [3.3,3,3.3,3,3=>3.1] 24R. **A** [3,3,3.7,3,3=>3.1]

## Appendix F: Classroom Implementation Summaries

Classroom Implementation Summary: *Arlene*

*Arlene* (fictitious name) is a school teacher in the southwestern United States. She integrated *Stream Flow for the Animus River* into a class of 6th grade gifted students. To ensure that the material in this module was new to the students, Arlene had a session of brainstorming with them. They knew that the Animus River was near Durango, Colorado, but by and large none had ever seen it. Likewise, they had little idea of the notion of stream flow. She had a computer in the classroom with a projector. However, because it was not possible in her school for students to have daily access to a computer lab, Arlene created her own activity sheets for them; they are attached to this summary. She also used the following web site as a follow-up for student questions on measuring the river: http://ga.water.usgs.gov/edu/measureflow.html

Generally speaking, the implementation of the unit went well. The best part for Arlene was that the students used Google Earth to travel north, looking for the headwaters of the Animus River. She was surprised that the students had little awareness of scientific notation. Another problem arose in question 1; everyone got the wrong number because they forgot to square 5280. However, all the steps they took after that were correct. Arlene thought that that was a good learning experience for the students. The second day they found their error and corrected the rest of the data. Even with these predicaments, the reactions of the students were good. (Note that approximately 25% of the students are Native American and there was virtually no difference between the two groups.) They especially liked Google Earth.

All of the students were successful on the test for the module. (This assessment is included at the end of the activity sheets.) The lowest grade was a 75.

It should be noted that a follow-up activity to the module occurred approximately one week after its conclusion. The class had a guest speaker: a father of one of the students who happens to work at a water station on the Animus River!

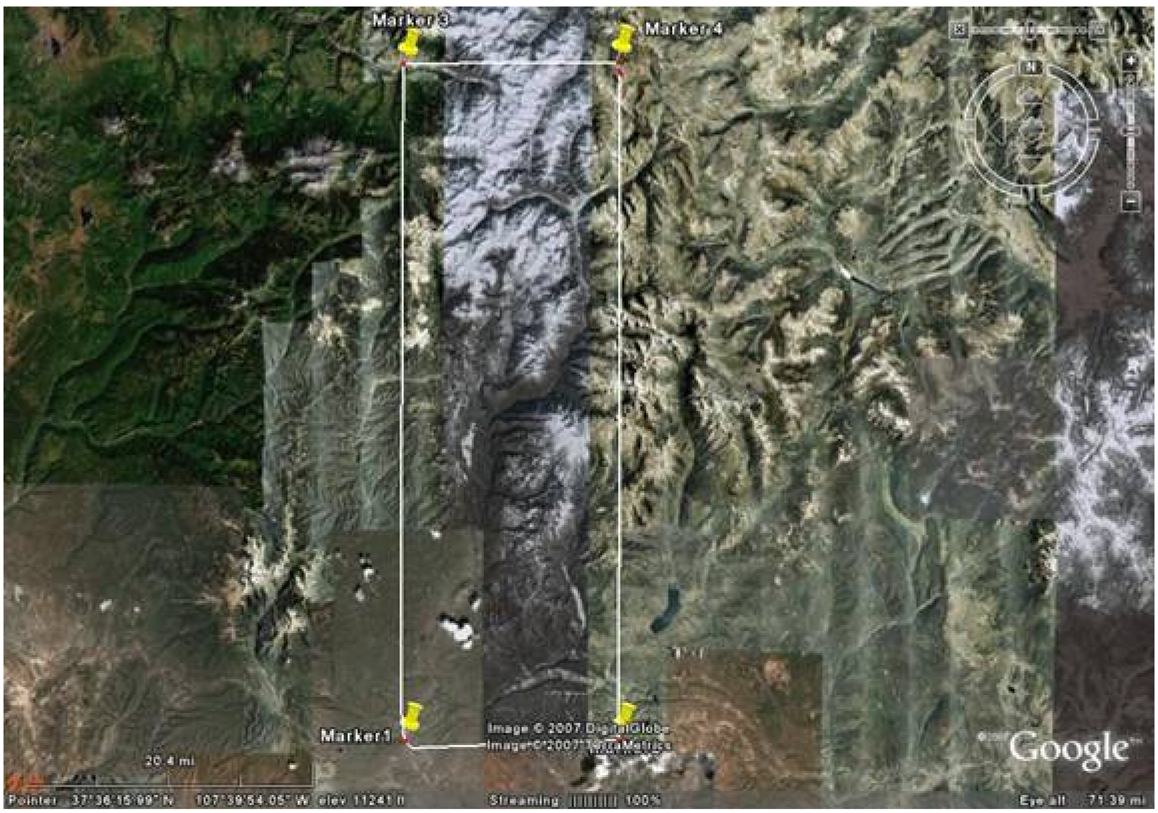
**Keyah Math Project – Student Packet ________**

# http://keyah.asu.edu/lessons/StreamFlow/KM1a.html

**Stream flow for the Animas River**

**Using Math to Find the Stream flow for Animas River**
The questions that follow will lead you to figuring out the average monthly stream flow for the Animas River at Durango. We will measure this in cubic feet per month, then convert to cubic feet per second, the most common units used for stream flow in this country.

The first step is to estimate the area of the drainage basin. Figure 1 shows the approximate drainage basin for the Animas from source to Durango. Of course, the actual watershed is not rectangular but this shows the approximate region.




Information you'll need to answer this question is bulleted below, refer to the figure shown, then answer the question below the figure.

- The area of the drainage basin, or watershed, for the Animas from source to Durango is roughly 700 square miles.

## Using math to estimate average stream flow for the Animas River

### Question 1: What is the area of the watershed in <u>square feet?</u>

hint: (1 mile = 5,280 feet, so 1 square mile = (5280 ft)*(5280 ft) = 52802  square feet)

***Please show your work:***

***My answer:***

### Question 2: Convert the annual amount of precipitation from inches to feet.

(1 foot = 12 inches)

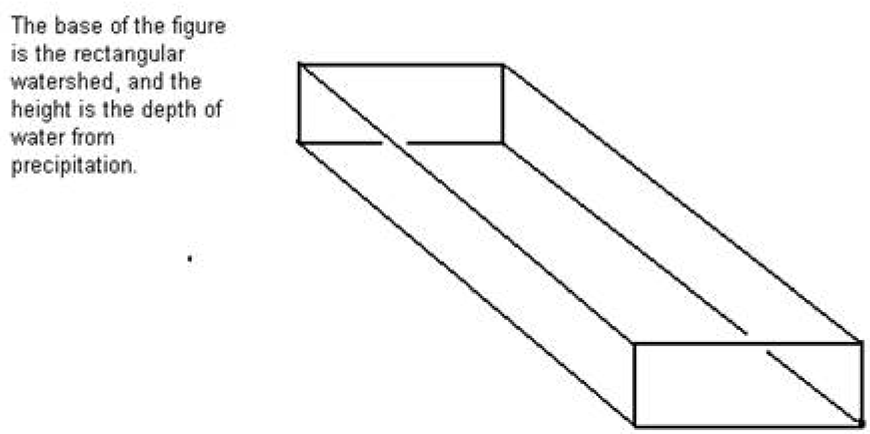
***Please show your work***

***My answer:***

**Question 3: Think of the drainage basin as a giant box with a rectangular base with area 700 square miles and height the amount of precipitation over the area, 22.17 inches. (See figure below.)**

***Now, find the total volume (in cubic feet—use your answers to #1 and 2) of water from rain and snow that falls on the watershed each year.***

(Volume = Area of Base x Height)




***Please show your work***

***My answer:***

Question 4: **Only 74% of the rain actually reaches the river bed to contribute to its stream flow (all the rest of the water is evaporated or diverted for other uses).**

***What is the annual stream flow for the Animas River?***

***Please show your work***

***My answer:***

| |
|---|
| |

**Question 5: On the average, how much water flows down the river each month? Each second?**(1 year = 365.2 days, 1 day = 24 hours, 1 hour = 60 minutes, and 1 minute = 60 seconds)

Your answer to # 5 is the average stream flow for the Animas River at Durango; the units should be cubic feet per second, or cfs.

***Please show your work***

***My answer:***

| |
|---|
| |

# Reflections

**Looking back at your answers**

- Do you think that the methods used here would be accurate for predicting future stream flow? Why or Why not?

- Do you think that you can accurately predict daily, or monthly, stream flow from annual stream flow, particularly for the Animas River? Why?

- What variations in precipitation might affect monthly stream flow?

- How would variations in stream flow affect the stream bed, or the land around the stream?

You might refer to the website **http://pubs.usgs.gov/of/1992/ofr92-129/hcdn92/hcdn/ascii/monthlya/region14/09361500.amm**, average the data given there, and compare to your answers.

Since much of the Animas River watershed lies in the San Juan Mountains at elevations from 8,000 to 14,000 feet, snow and snow melt drastically affects its stream flow. Again, see the website listed above. For a better look at how Animas stream flow is affected by snowfall, go to KM Study #2, "Snowfall and the Animas River Stream Flow."

***You have finished! For more fun projects check out the other modules at***

http://keyah.asu.edu/

Science Follow up - Name______________________________

15 pts1. What does Keyah mean?

15 pts 2. What does "cfs" stand for?

40 pts 3. Please give two similarities and two differences between the Animas River and the San Juan River.

20 pts 4. Why does the stream flow of the Animas River change in different seasons of the year?

5 pts 5. What would you like to learn more about after doing this project?

5 pts 6. What would you recommend doing to make this project better?

Classroom Implementation Summary: *Barbara*

*Barbara* (fictitious name) is a Geologist Professor at an undergraduate institution in the southwestern United States. She used the module, *Meteor Crater*, in her introductory geology course, Geologic Disasters. This course is 90% non-science majors and it has no mathematics prerequisite.

The unit was used as part of an in-class activity and it was assessed via a weekly quiz. To ensure that the material was new to the students, Barbara asked the students several key questions which they answered in their required notebooks. This assignment constituted the pre-test; the weekly quiz was the post-test.

Generally speaking, Barbara believed that the unit went "better than [she] thought, but not as well as [she] had hoped." Even though many of the students did not know how, she was impressed at how they were not afraid to begin. Moreover, most were able to handle the scientific notation. In addition, the reaction of the students over all was "pretty good. [They were] a little anxious about having to replicate the calculations on a quiz." However, after they were "presented with the problem, most went right to work."

The worst part for her was trying to tie the module into her curriculum. However, she may still use the *Location of the Epicenter of an Earthquake* later on in the semester. She was surprised at the amount of class time was needed and, also, that the students did not seem to "understand that you can determine mass or energy using the same formula."

After the module was completed, the students generally had a pretty good notion of how craters were formed. Several of them had an intuitive understanding of the effect of kinetic energy, but there was little understanding of this concept. If she were to teach this module again, she would think more about what questions she would want them to answer, i.e. "what Big Picture ideas?" For example, she might decide to explain that the diameter of a crater is approximately 10 times the size of the bolide. Or she might ask them to compare/contrast Meteor Crater and Chicxulub Crater, the crater in the Yucatan that is linked to the extinction of the dinosaurs.

It was not possible to interview any of the students without being sanctioned by her institution’s Institutional Review Board.

## Classroom Implementation Summary: *Carl*

Carl (fictitious name) is a geologist who teaches science in a high school in the southwestern United States. He tested *The Size of the Earth* in four Physical Science classes because it fit perfectly into her curriculum. To ensure that this material was new to the students, his warm-up for the day consisted of some geometry, e.g., diameter and circumference of a circle. (Because there was little awareness of these concepts, this activity also served as a pre-organizer for the pending module.) Computers were not available for each of the students, so he copied the module, from the web, site and gave each one a hard copy. Except for making modifications to the last two questions, he used the module exactly as it was written. In addition to his science classes Carl planned to present the module to the mathematics teachers in hopes that one or more of them might use them in their mathematics classes, as well.

Generally speaking, the implementation went very well. The students "loved it!" The best part for the students was the story about Eratostenes at the beginning of the module and the nearness of his "ancient calculations to the *real* size" that we calculate today. Many of them determined that "the poles were their technology." This was very insightful of them and one of the best parts of the activity for Carl. He also liked using mathematics in science. For many of the students, the key sequences necessary to complete the calculator calculations were challenging. A surprise for Carl was the students' lack of understanding of scientific notation and significant figures necessary for accurate answers. However, the assessment for the activity was very successful: the questions were answered with 80% accuracy. Approximately 25% of Carl's students are Native American. There was no distinguishable difference between the reactions of the two groups, Native American or Non-Native American.

Carl liked using the module so well that he plans to use another before the school year is over. Moreover, other teachers in his department will use it this year, as well!

Classroom Implementation Summary: *Dan*

Dan (fictitious name) is a Mathematics Professor at a college in the southwestern United States. He tested two modules, *Stream Flow for the Animus River* and *Snow Melt and Stream Flow the Animus River,* in his Introduction to Algebra class. He chose these modules because they used linear equations. To ensure that the material in the module was new to the students, Dan gave a quiz before the beginning of the unit with several general questions that related to the module. (The questions ranged from such items as 'Any awareness of Keyáh Math?' to 'What would you expect to discuss in the topic of stream flow?') Students had access to a computer lab where they worked on the modules independently.

Generally speaking the reaction of the students was good. They liked the web site because it was something different from the text book. However they had difficulty reading the text: they wanted more pictures and a larger font. The "second one was just on the edge of being long, but they liked it!" They wanted "more assignments like these to improve their awareness" of the world around them.

For Dan, the unit was "OK." The best part for him was the positive reactions of the students: "Wow!;" "I haven't seen anything like this;" "[This is] better than myspace or utube." Clearly they liked what they saw. He was surprised at how the students [finally] realized during the activity that conversion IS important. In fact, they need to be "very careful or [it gets] very messy." And like a parent he badly wanted to say, "I told you so!"

At the conclusion of the unit <u>all</u> of the students know the information from the web site. Therefore, the posttest was very, very successful. When Dan teaches the unit again in the fall, he will give it more time. After introducing the topic to the students he will give them a week to work on it. Over 50% of his students are Native American. There was no discernible difference between that group and the Non-Native Americans.

Classroom Implementation Summary: *Elaine*

*Elaine* (fictitious name) is a geologist at a four-year college in the southwestern United States. She integrated *Sunset Crater* into an entry level, general education, 100-level course, for non-science majors, *Earth Shock: Natural Disasters, Cause and Effect.* *Sunset Crater* fit right into her curriculum, in the unit of earthquakes.

The module was used without modification as an in-class activity that took approximately one week. To ensure that the material in the module was new to the students, Elaine created a set of 10 questions that were used as a pre-test. Five of these items were used later as a post-test. The pre-test is attached to this summary.

Generally speaking Elaine believed that the module went well. "Most of the students (75% - 80%) were able to set up all of the equations and got solutions." She thought that the best part was the high portion "who could understand the problem and the results." And, she was surprised at the "number of kids who couldn't " even get started. But, the worst part was the fact that the module is lacking a digital component. There is "a link to Stromboli, but" she did not use it.

Elaine did not modify the module in any way this first time she used it. However, the next time she uses it (and she will use it, perhaps with junior and senior geology majors), she will use the Stromboli link first, then use the module to allow the students to see the geology from a mathematical point of view. When the module is completed, she will go back to Stromboli, perhaps even using the equations and other information from *Sunset Crater.* Again, "it would be nice to see this in the module."

Even though 15% - 20% of the students could not do it, after it was completed the best part of module for a majority of the students was "applying math to [solve a] geologic problem. Approximately 7% of the students are Native American.

***Earth Shock Exercise W2008***
***Using Math to Explore Volcanic Processes***
***Due On Monday April 14, 2008***

**PART 1: Using a scale of 1 to 10 (10 being the highest rating and 1 being the lowest) rank the following categories on the basis of YOUR experiences before you complete the Sunset Crater module activity.**

| Topic | Pre Module |
|---|---|
| Interest in Science | _____ |
| Interest in Natural Disasters | _____ |
| Interest in Volcanoes | _____ |
| Understanding of How Pyroclastics are Erupted from Volcanoes | _____ |
| Understanding of Impacts of Volcanoes on Humans | _____ |
| Location of Sunset Crater Volcano | _____ |
| Knowledge of Volcanic History of Sunset Crater | _____ |
| Interest in Mathematical Concepts in Relation to Natural Disasters | _____ |
| Ability to Use Mathematical Solutions to Solve Problems | _____ |
| Application of Math to Solve Science Problems | _____ |

PART 2: Go to http://keyah.asu.edu/fixed-map.html

Select the Volcanic Processes-Sunset Crater Northern Arizona module. This exercise was designed to show the application of mathematics to explain and solve geologic (natural disaster) problems. I am having you do this exercise to experience how math can be used to explain a natural phenomenon, and to assess the effectiveness of this module.

Read the information presented in the module and complete the questions. Turn in parts 1 and 2 on Monday, April 14.