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AUTHOR Boone, William J.
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ABSTRACT

Two key factors affecting the success of non-major science courses are students' perceptions of topic difficulty and interest. An attitudinal survey administered to 300 college students, after completion of a college science course, evaluated their attitudes toward a geology curriculum. Using a Likert type scale students rated their level of interest and the degree of difficulty for 15 specific class components. Some of the topics investigated were: (1) differences between rocks and minerals; (2) metamorphic rock formation; (3) reading a topographic map; and (4) the role wind plays in erosion. Analysis of the results analyzed by the stochastic Rasch model revealed that although some correlation exists between "difficulty" and "least interesting" topic, there were some topics viewed as both difficult and interesting. Three implications for earth science courses were provided: (1) incorporate the techniques (pictures, real life experiences) which interest students in topics that they are less interested in; (2) develop new methods to teach students to use topographic maps; and (3) present sedimentary rock formation after igneous and metamorphic processes. The development of geology curricula from an approach that considers students' interest and the science topics' level of difficulty can aid educators in making necessary revisions in geology courses. (ZWH)

Evaluating a Geology Curriculum for Non-Majors

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Dr. William J. Boone
Program in Science Education
School of Education 3068
Indiana University
Bloomington, IN 47405
(812) 856-8132

Introduction:

Two key ingredients effecting the success of non-major science courses are students' perceptions of topic difficulty and interest. If material is too difficult (beyond the background of those enrolled) then students may be turned off. Likewise, if material is not very interesting- then non-majors may quickly become uninvolved in a course. Since these courses are often one of the few "science" courses taken by non-majors, it is critical that such a class ignite an interest in science which will last a lifetime. Certainly this is important for the literacy of our country.

In an effort to evaluate students' attitudes towards a geology curriculum, an attitudinal survey was administered in the spring term of 1992. The instrument asked respondents to consider how interesting and difficult they found 10 lecture topics and 5 labs. Collecting data on these two aspects of a geology curriculum enabled an assessment to be made of class material presentation order as well as the suitability of lab and lecture instruction. How would the nearly 300 hundred students react to the topics? Would there be a clear and predictable ordering of topics, or would students differ in their view of topic interest and topic difficulty? How would students vary in their reaction to the curriculum as a function of age, major, gender, academic standing and lab section instructor? As this class is often one of the few college science lab courses these students complete, it was critical to evaluate this facet of the curriculum and weigh the results in light of instructional practice and class organization. It is indeed true that the success of a geology curriculum is dependent upon many factors independent of subject matter (i.e. teaching style, text), however, this study stressed the collection of attitudinal data to furnish practical information on students' attitudes toward a curriculum. Following such a data collection, these types of data can be utilized to improve a course.

Previous Work:

A number of researchers have previously developed and/or utilized attitudinal instruments to supply information helpful for science education efforts. Enochs and Riggs (1990) used a Likert scale to measure the science teaching efficacy beliefs of elementary science teachers. Stefanish and Kelsey (1989) utilized the Shrigley Science Attitude Scale for Preservice Elementary Teachers (Shrigley, 1971) to measure the beliefs of preservice elementary science teachers toward science and science teaching. Hartly et al. (1984) employed an attitudinal instrument (Shrigley and Johnson, 1974) to investigate, in part, whether differences in preservice teachers' attitudes could be traced to differences between two methods courses.

This study was carried out to extend the research base to that involving the collection and evaluation of likert scale data (Thurstone, 1928) with a population of students who were completing a science course. Many researchers have considered how to change student attitudes toward science teaching (i.e. Morrisey, J.T., 1981), but research regarding attitudes toward class topics presented in science courses seems to be lacking. These data can be useful not only in the planning and reforming of a geology curriculum, but also in better understanding the attitudes of students towards science. Furthermore, future elementary science teachers often take these non-major courses. If elementary science instruction is to be improved- such courses need to be evaluated.

Data Collection:

At the end of the spring 1992 term an attitude survey (topics listed on next page) was administered to students completing a geology course at Indiana University-Bloomington. This course is taken predominately by non-science majors. The instrument asked students to evaluate how interesting they believed 15 class components to be. The rating system used a four step likert scale (very interesting, interesting, disinteresting, very disinteresting). A second set of ratings was also requested of students. This part of the survey asked students to describe "how difficult it was to learn" each of the 15 topics. The second rating scale also utilized a four step scale (very easy, easy, difficult, very difficult). In addition, demographic data regarding the respondents gender, age, major, academic standing and lab section were also collected. The surveyed categories are provided on the following page. Many other topics were covered during the semester, but in order to present students with a manageable survey, a limited number of class components were used for survey construction. Surveys were administered during April of 1992. More than 95% of enrolled students furnished data for this study.

1- The difference between rocks and minerals.

2- The rock cycle.

3- Using cross-cutting relationships to determine the relative age of rocks.

4- The way sedimentary rocks are formed.

5- The way igneous rocks are formed.

6- The way metamorphic rocks are formed.

7- Mineral resources in the world.

8- The landforms caused by glaciers.

9- The role wind plays in erosion.

10-The way shorelines are created.

11-To identify minerals as in lab #1.

12-To identify igneous rocks as in lab #2.

13-To identify sedimentary rocks as in lab #3.

14-To identify metamorphic rocks as in lab #4.

15-To read a topographic map as in lab #5.

Data Evaluation:

The stochastic Rasch model (Rasch, 1960) was used to evaluate these data. This evaluation technique was selected because the ordinal attitudinal scale must be first converted to an interval scale. This step can best be understood by noting that a step in attitude from "excellent" to "very good" does not necessarily represent the same quantifiable change in attitude as steps from "very good" to "good" (i.e. Thurstone, 1929; Wright and Masters, 1982). This method of analysis is also well suited for these data because 1) it allows an evaluation of persons and items when data is incomplete (i.e. each survey respondent must not respond to every item), 2) errors of each surveyed item and respondent are reported, 3) statistics which help indicate the relevance of items are provided, and 4) persons and items are plotted on the same scale. The FACETS computer program (Linacre, J.M. and Wright, B.D., 1991) was utilized.

Data Interpretation-Items:

In Table 1 the results of the students' class components ratings (for interest) are presented. The class component with the highest logit value (Item 15: Reading Topographic Maps) was viewed by students as the least interesting topic. This item was rated, on average, as being between "interesting" and "disinteresting" by students. Items positioned above this item (less positive logit calibration) represent class topics viewed in a more favorable manner by students. The item at the top of Table 1 (Item 8: Glacial Landforms) was viewed most positively by students with an average rating of approximately "interesting". By noting the error present in each calibrated item, true statistical differences in items can be observed. Table 2 displays summary data for each rated "interest" item.

Table 1:

Item Topic (Abbreviated)		Calibration	Error
Most Interesting		**Logit Interest Units**	
8	Glacial Landforms	-.81	.11
7	Mineral Res in World	-.51	.11
10	Way Shorelines Created	-.34	.11
9	Role of Wind in Erosion	-.08	.11
11	Identify Minerals	-.06	.11
13	Identify Sedimentary Rx	.02	.11
12	Identify Igneous Rx	.04	.11
14	Identify Metamorphic Rx	.07	.11
6	Way Metamorphic Rx Form	.11	.11
5	Way Igneous Rx Form	.11	.11
1	Difference Rx and Mineral	.13	.11
3	Cross Cutting For Age	.26	.11
4	Way Sedimentary Rx Form	.27	.11
2	Rock Cycle	.27	.11
15	Read Topographic Map	.52	.11
Least Interesting			

Table 2:

Summary Statistics of Item Calibrations Based on "Interest"

	Average	Measure Logit	Model Error	Outfit Std
Mean	1.2	0.00	.11	-.4
SD	0.1	0.32	.00	3.4
Reliability 0.89				

Measure Logits- Measures in Logits; Model Error- The standard error of the measure in logits; Reliability- True Variation/Observed Variation

```
                         Least Interesting

                              *
                              * .50 logits <- 15 Read Topographic Map
                              *
                              * .4
                              *
                              * .3
    4 Way Sedimentary Rx Form *    <- 3 Cross Cutting For Age\2 Rock Cycle
                              * .2
                              *     <- 1 Difference Rx and Mineral
    5 Way Igneous Rx Form ->  * .1  <- 6 Way Metamorphic Rx Form
 12 Identify Igneous Rx   ->  *     <- 14 Identify Metamorphic Rx
                              * 0 logits <- 13 Identify Sedimentary Rx
     11 Identify Minerals->   *     <- 9 Role of Wind in Erosion
                              * -.1
                              *
                              * -.2
                              *
                              * -.3 <- 10 Way Shorelines Created
                              *
                              * -.4
                              *
                              * -.50 <- 7 Mineral Res in World
                              *
                              * -.6
                              *
                              * -.7
                              *
                              * -.8 <- 8 Glacial Landforms
                              *
                              * -.90

                         Most Interesting
```

In Table 3 the results of the students' class components ratings for difficulty are displayed. The class component with the highest logit value (Item 15: Reading Topographic Maps) was viewed by students as the most difficult topic. This item was rated, on average, as being between "easy" and "difficult" by students. Items positioned above this item (less positive logit calibration) represent class topics viewed by students as being easier. The item at the top of Table 3 (Item 9: Role of Wind Erosion) was viewed most positively by students with an average rating of approximately "easy". By noting the error present in each calibrated item, true statistical differences in items can be observed. Table 4 displays summary data for each rated "difficulty to learn" item.

Table 3:

Item	Topic (Abbreviated)	Calibration	Error
Least Difficult		**Logit Difficulty Units**	
9	Role of Wind in Erosion	-.56	.12
6	Way Metamorphic Rx Form	-.42	.12
4	Way Sedimentary Rx Form	-.41	.12
5	Way Igneous Rx Form	-.33	.12
1	Diff Rx and Mineral	-.33	.12
7	Mineral Res in World	-.26	.12
2	Rock Cycle	-.23	.12
12	Identify Igneous Rx	-.15	.12
14	Identify Metamorphic Rx	-.11	.11
13	Identify Sedimentary Rx	-.01	.11
11	Identify Minerals	.20	.11
10	Way Shorelines Created	.30	.11
8	Glacial Landforms	.38	.11
3	Cross Cutting For Age	.65	.11
15	Read Topographic Map	1.27	.10
Most Difficult			

```
                           Most Difficult

                                 * 1.3
                                 *     <- 15 Read Topographic Map
                                 * 1.2
                                 *
                                 * 1.1
                                 *
                                 * 1.0
                                 *
                                 * .9
                                 *
                                 * .8
                                 *
                                 * .7
                                 *     <- 3 Cross Cutting For Age
                                 * .6
                                 *
                                 * .50 logits
                                 *
                                 * .4
                                 *    <- 8 Glacial Landforms
                                 * .3 <- 10 Way Shorelines Created
                                 *
                                 * .2 <- 11 Identify Minerals
                                 *
                                 * .1
                                 *
                                 * 0 logits <- 13 Identify Sedimentary Rx
                                 *
                                 * -.1 <- 14 Identify Metamorphic Rx
                                 *     <- 12 Identify Igneous Rx
                                 * -.2 <- 2 Rock Cycle
                                 *     <- 7 Mineral Res in World
      5 Way Igneous Rx Form ->   * -.3 <- 1 Diff Rx and Mineral
                                 *
  4 Way Sedimentary Rx Form->    * -.4 <- 6 Way Metamorphic Rx Form
                                 *
                                 * -.50
                                 *      <- 9 Role of Wind in Erosion

                           Least Difficult
```

Table 4:

Summary Statistics of Item Calibrations Based on "Difficulty to Learn"

	Average	Measure Logit	Model Error	Outfit Std
Mean	1.2	0.00	.11	-.5
SD	0.1	0.47	.00	4.0

Reliability .94

Measure Logits- Measures in Logits; Model Error- The standard error of the measure in logits; Reliability- True Variation/Observed Variation

(Please see next page for continuation of text.)

Results:

Results of the analysis indicate that although there was some correlation between "difficulty" and "least interesting" (topographic maps and cross cutting relationships) there were some topics viewed as both difficult and interesting (for example glacial landforms). Statistics also indicated that students did not respond in a predictable manner to the "difficulty" of topographic maps and the identification of minerals. This meant that students' responses to the other survey items fell in a predictable pattern, but not so with these items. These data also showed unpredictable responses with regard to "interest" in topographic maps and mineral resources of the world. The lack of student consensus with regard to these topics and lab activities is of great importance in the design of this curriculum. Many deductions can be made from the ordering of items by interest and difficulty. A few interpretations will be presented here in this paper, however, the presenter hopes that the audience will provide their own insights into the ordering of geology topics.

Curricular Implications of Item Interest Order:

The surveyed topics are all commonly presented in an introductory geology course, both at the major and non-major level. The three most highly rated items (glacial landforms, mineral resources, creation of shorelines) are distinctly different in calibration that the other items. The shoreline and glacier topics may be most interesting, because discussion (i.e. slides of shores and glaciers) of this topic involves the consideration of information which is probably familiar to students. Most students have seen pictures of mountains, have wondered why glacial terrain is so beautiful, or have walked along the shoreline. Mineral resources (searching for gold, silver, oil) may be interesting because students have always wondered how these riches are discovered. The remaining items (with the exception of "topographic maps") fall roughly in the same interest level, however there are some

differences to be noted.

*The three class labs (identifying sedimentary rocks, metamorphic rocks, and igneous rocks) were rated at about the same interest level. Thus by interest no curricular ordering of these three topics is suggested.

*Determining age with cross-cutting relationships is often difficult for students. This may be because they not only have to translate a 2-dimensional map into 3-dimensions, but they must also consider the variable "time". Low interest may be related to the way the topic is presented and the difficulty of activities commonly used to explain the topic.

*Sedimentary rock formation takes place in many more steps that of metamorphic and igneous rock formation. This may explain why this topic (of the three) is more difficult, and less interesting.

*Topographic maps are indeed quite difficult to read. Usually students have not seen such maps before, and the process of decoding 2-dimensional information into a 3-dimensional picture can be demanding. This may explain a lack of interest.

Possible overall implications for earth science courses are: 1) make use of the techniques (pictures, real life experiences) which interest students in topics such as glaciers when other topics are presented, 2) develop new ways of teaching about topographic maps, 3) present sedimentary rock formation after igneous and metamorphic rock processes.

Curricular Implications of Item Difficulty Order:

Not only is it important to note how "interesting" a topic was for students, but it is equally important to note how "difficult" a topic was for a class. Two most intriguing pieces of information are revealed by a comparison of "glacial landform" and "shoreline creation" difficulty and interest. Although these topics were viewed as quite interesting, these topics were not viewed as being among the most easy topics. Perhaps students' everyday experiences helped them maintain interest in a difficult topic (it certainly is indeed difficult to interpret glacial terrain). The ratings of labs which involved the identification of rock types and minerals indicate that students viewed mineral and sedimentary rock identification as more difficult than the identification of metamorphic and igneous rocks. Perhaps igneous rocks should be introduced first in a curriculum. Following this topic one could present labs involving (1st) metamorphic rocks, (2nd) sedimentary rocks, and (3d) minerals.

Conclusion:

The administration of the geology interest and difficulty survey revealed that students held a wide range of beliefs with respect to these 15 components of a university geology curriculum. Furthermore, a curriculum framework emerged as a function of the interest and difficulty data. This analysis helps point to parts of the lecture and lab curriculum which require possible revisions. Also, the results help illuminate which segments of the course are viewed in an unpredictable manner-indicating which parts of the present curriculum and instruction is working well for some students, but not so well for others.

Educational and Scientific Importance of this Study:

From both an educational and scientific perspective this study is important. This inquiry supplies detailed data on students' reactions to a specific curriculum. This work is very important for those interested in investigating a curriculum so as to improve the presentation of subject material and thus the education of students. The scientific strength of this project is it demonstrates the usefulness of this particular statistical model with respect to these types of data. Furthermore, the results not only help in educating these students, but broaden scientific knowledge regarding the way in which a wide range of students view an introductory liberal arts and sciences geology curriculum. Such studies certainly should not be limited to geology, for important curricular advice could be provided for many classes!

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