USE OF SEMESTER LONG DATA/RESEARCH PROJECTS IN INTRODUCTORY EARTH SCIENCE COURSES

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Abstract:

Semester long research projects as a partial substitute for traditional laboratory exercises have been implemented in two, two-semester long Introductory Earth Science sequences. One sequence is designed for traditional age students, the other for an accelerated format course of non-traditional age students. Each semester students develop a research question, propose a testable hypothesis, and test the hypothesis using web-based data sets. In the first semester, research questions center on flood frequency behavior during the traditional student course. Students access surface water data from the USGS National Streamflow Information Program (NSIP) website. Earthquake distribution and plate tectonics are the focus for the non-traditional age students' research projects. The students use an interactive computer program called Seismic/Eruption or SeisVolE to collect and organize seismic data from the USGS. The second semester in both course sequences focuses on questions related to global climate change. Data is obtained from NOAA's National Climate Data Center, or NASA's TOPEX/Poseidon website. Prior to the selection of their research question, students engage in laboratory activities to introduce them to the datasets and/or software that they are likely to use. At the end of each semester of study, students are required to prepare a poster presentation and a short oral presentation of their results. This exercise is to simulate a poster session at a professional, scientific conference.

Introduction:

The use of active and collaborative student-centered activities to promote a better understanding of the nature of science has been recommended by a number of sources (Yuretich et al., 2001, Palmer, 1998, D'Avanzo et al, 1997; Springer et al., 1997; NRC, 1996; AAAS, 1990).

Pedagogical strategies to promote this type of learning have been recommended by the National Research Council (NRC, 1996) and by AAAS Project 2061 and include: inquiry-based learning, active engagement of students, collaborative learning, ongoing assessment, and establishing a community of learners.

In order to best understand the nature of science, students need to have experience with the types of thought and methods of study that are typical of the sciences, which means teaching science as it is practiced.

Logistics:

Successful completion of the projects requires student access to networked computers with Internet browsers and a spreadsheet program. For research questions in the areas of seismology and plate tectonics, we have students utilize the SeisVolE freeware program that is available for downloading from:

http://www.geol.binghamton.edu/faculty/jones/.

Projects are conducted in three member teams. It is the responsibility of the team to divide the work in an equitable manner, and the team is responsible for making sure everyone completes his or her assigned responsibilities.

The project should be introduced during the first week of class in order to establish an achievable timeline.

Objectives:

In order to provide a more inquiry based experience for students, we have introduced semester long research projects that utilize Internet databases for students to propose and test hypotheses related to the earth sciences.

Upon successful completion of the projects, students should be able to:

- Describe the earth sciences as a human activity that, in part, deals with a variety of problems that societies face when interacting with the environment
- Describe the scientific process of investigating phenomena, including:
  - Articulating valid research questions
  - Formulating a testable hypothesis
  - Describing observations that would support or refute the hypothesis
  - Collecting data and evaluating the validity of the data collected
  - Synthesizing data
- Describe the usefulness and limitations in the use of modeling to comprehend earth processes

Students also gain a deeper understanding of a number of content areas covered in the two semester sequence, including:

- Distribution of earthquakes and their relationships to plate tectonics
- Stream behavior and flood prediction
- The relationship of global climate phenomena (e.g. El Niño or La Niña)

The projects develop a number of other skills that students have found useful, including:

- Internet search skills and the ability to discern websites with trustworthy data
- Spreadsheet skills, including simples statistics and graphing
- Team building skills

	Plate Tectonics	Streams & Flooding	Ozone Depletion	Seafloor Data	El Niño & La Niña
On-line Databases/Software:	http://www.geol.binghamton.edu/faculty/jones/ http://earthquakes.usgs.gov/recenteqs/ http://earthquakes.usgs.gov/recenteqsUS/Quakes/quakes_all.html	http://waterdata.usgs.gov/nwis	http://www.cpc.ncep.noaa.gov/products/stratosphere/polar/polar.html http://www.cpc.ncep.noaa.gov/products/stratosphere/tovsto/ http://toms.gsfc.nasa.gov/	http://walrus.wr.usgs.gov/mamalabay/index.html http://geology.wr.usgs.gov/wgmt/bostonharbor/boston.html	http://ivanova.gsfc.nasa.gov/outreach/EOSDIS_CD-03/docs/data.htm http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/bulletin/index.html http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_update/index.html http://www.ogp.noaa.gov/enso
Examples of Student Projects:	Number of Plate Collisions vs frequency of Earthquakes (Figure A) Cause of Intra-Plate Earthquakes Activity of Earthquakes Comparison of (3) stratovolcanic eruptions	Development of 500 Year Floodplain Map for Black Earth Creek, WI	Change in Size of Polar Ozone Hole Over Antarctica Over the Last 20 Years Comparison of Polar and Mid-Latitude Ozone Depression	Estimation of predominant direction of bottom currents from bottom photographs Comparison of heavy metal content (e.g. Cd, Hg) of dredge material to native sediment in Mamala Bay Comparison of burrowing activity in dredge material vs. native sediment from box core photographs Analyzing mercury deposits and toxicity levels in the Boston Harbor	Does El Niño have an Effect on Ice Average Duration of Lake Mendota, WI Cause of 1994 Mississippi flood Effect of El Niño and La Niña on Tornado Frequesncy in the Upper Midwest Wisconsin Crop Yeilds vs. El Niño and La Niña Does El Niño Effect Water Levels in the Great Lakes

Resources: Web-sites addresses for on-line databases/software and examples of previous projects that were successful.

Example of student project data based on SeisVolE and Excel software

Hypothesis: The number of lithospheric plates colliding will determine the relative number of earthquakes for the region.

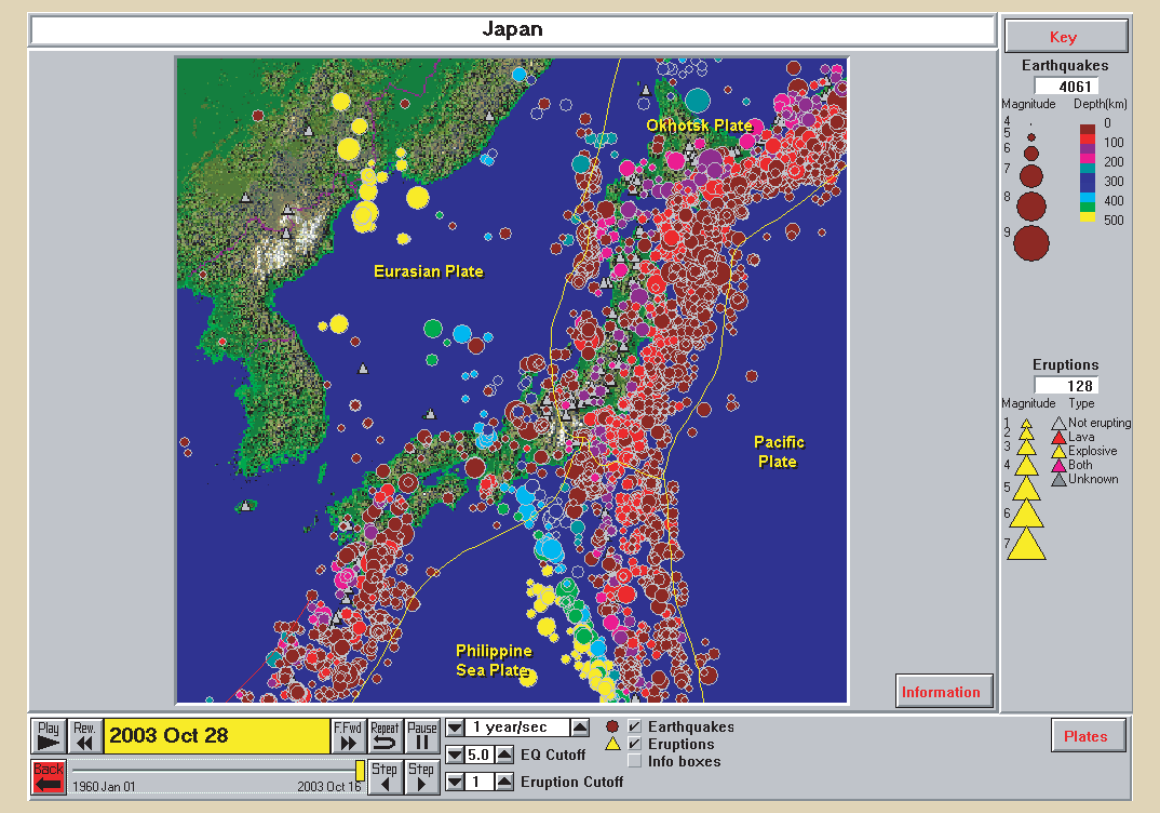

Figure 1: This map shows the earthquakes that took place during our study period for the Japan area. It also shows the four plates that are converging in this area. The plates are; The Pacific Plate, The Eurasian Plate, The Philippine Plate and The Okhotsk Plate.

Figure 2: This map shows the earthquakes that took place during our study period for the Central American area. It also shows the plate boundaries for the three converging plates. The plates are; The Cocos Plate, The Caribbean Plate, and the North American Plate.

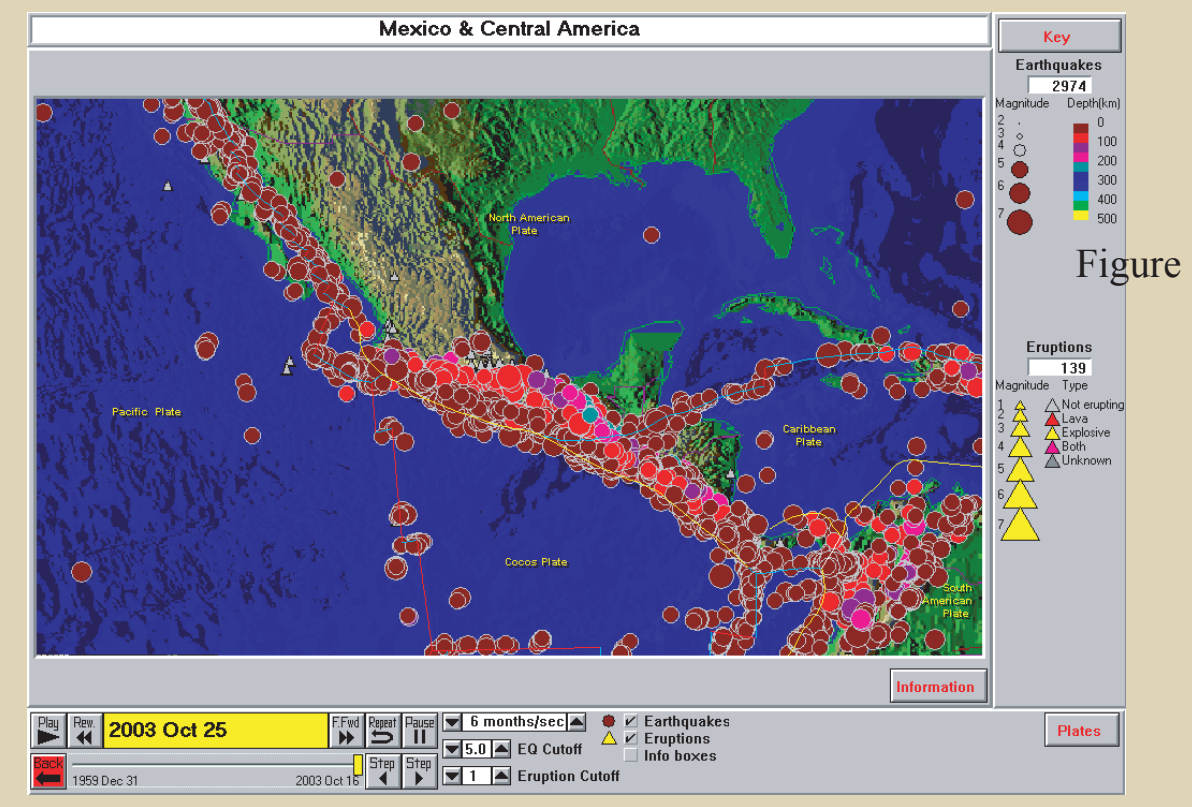

Figure 3:

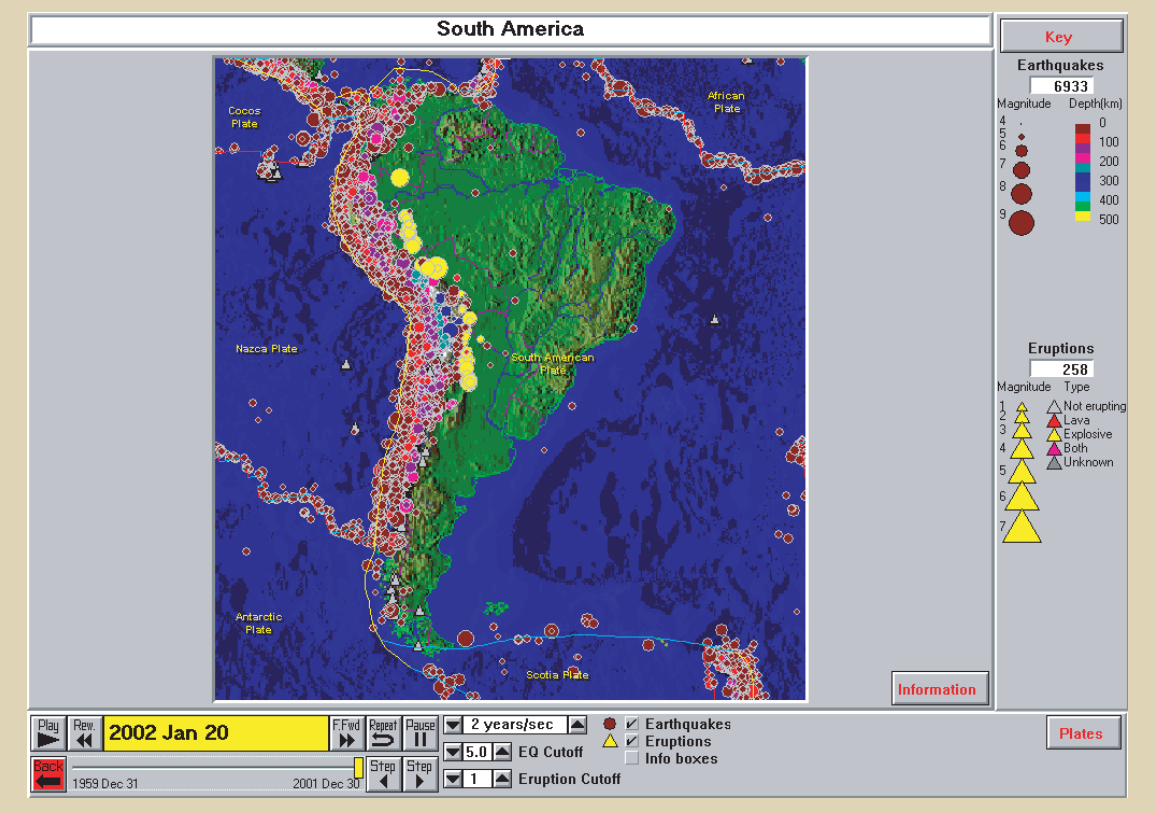

Figure 3: This map shows the two plates that are converging in the South American area. The plates are; The Nazca Plate and The South American Plate.

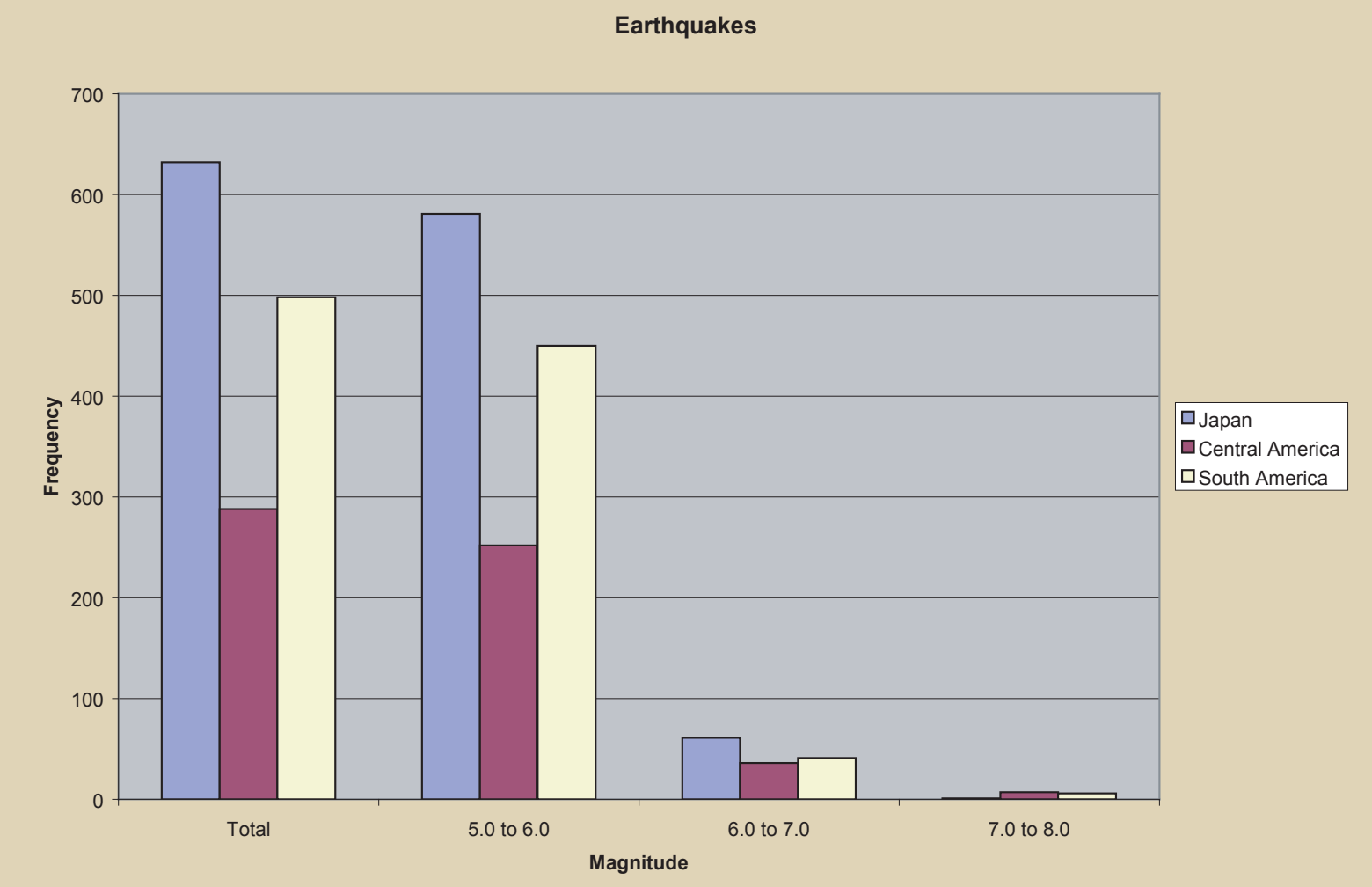

Figure 4: This graph shows the actual number of earthquakes for each area studied. Both the total number of earthquakes and also how the divided out by magnitude.

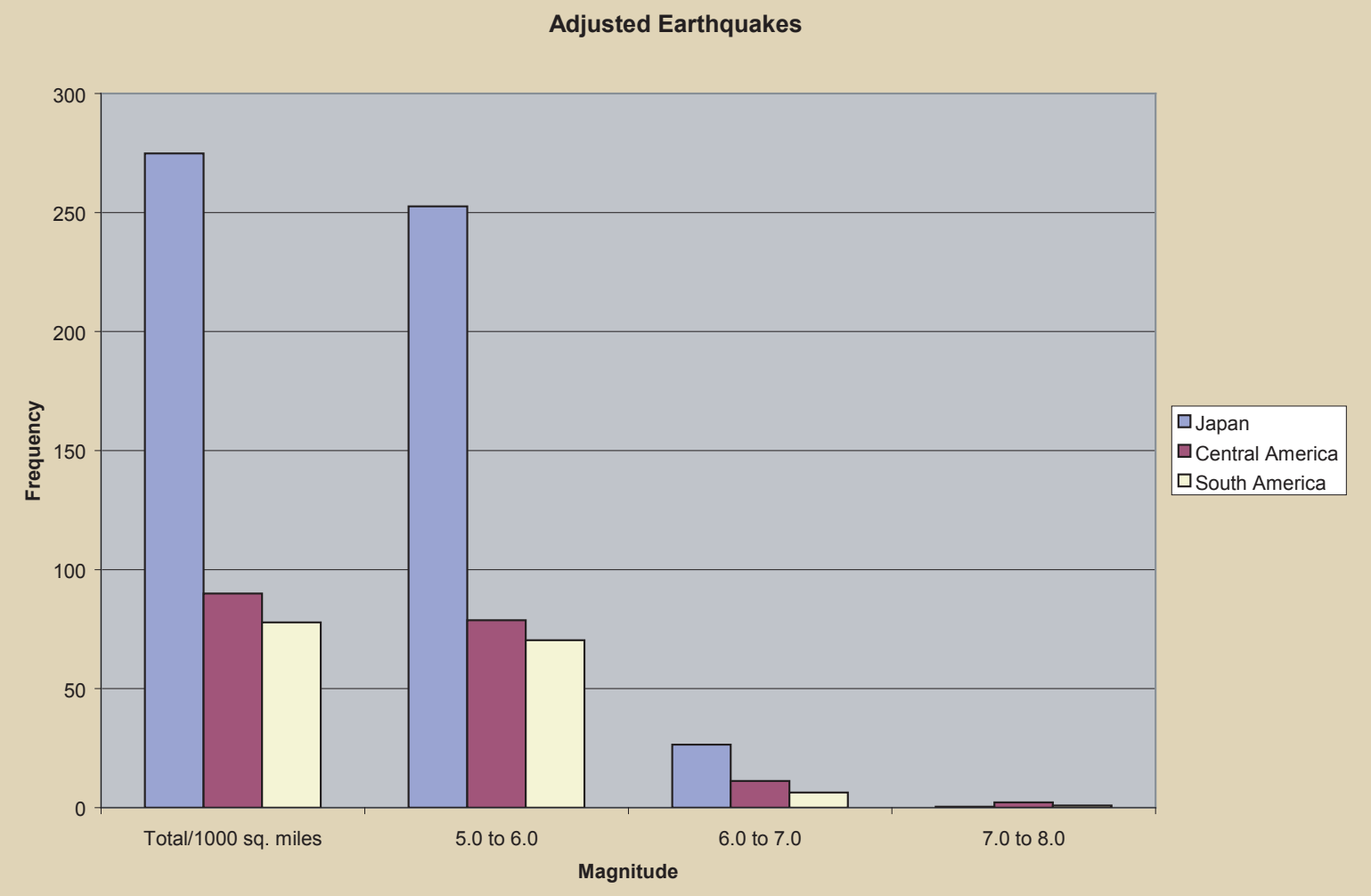

Figure 5: This graph shows both the number of total earthquakes and the division by magnitude for each area. The data has been scaled to 1 million square miles for each area.

Figure A: Student figures representing data obtained and analyzed. Students were attemting to prove that the number of plates colliding directly effected the number of earthquakes. The group discovered that in order for their results to be valid the land masses had to be of equal area (Figure 5).

Student Assessment:

Regardless of the format, the Final Project Presentation is graded on organization of ideas, clarity, appropriate level of information, depth and originality. Students are encouraged to check with the instructor about the outline of their presentation.

The scoring rubric is as follows::

Timelines Met - 20%

Informational Content – 40%

- *Title and authors*
- *Abstract* (Brief summary of the contents of the study)
- *Introduction* (Historical information and reason for the study - including a description or statement of the hypothesis being tested)
- *Methods* (Short description of the methods that were used to collect the data)
- *Results* (Description of the data including figures and graphs)
- *Conclusions* (What did you data tell you? Did your investigation support or refute your initial hypothesis. What new things did the data tell you? What new questions were raised?)
- *References* (Includes a minimum of three references at least one of which is not a website)

Presentation - 40%

Includes: neatness, organization, relevant visuals, creativity, amount of information, use of color and "readability"

Project Evaluation:

Student attitudes regarding the projects is gleaned from end of semester student evaluations. In Spring 2001, a survey was developed to assess student attitudes about the semester long projects. The survey was distributed at the end of the course asking specific questions with regard to the usefulness of the Research Project to their learning. The response to the survey was good with 42 of 44 students in the class returning surveys.

The following questions were asked:
1) As a result of the Research Project, I am better able to critically evaluate societal problems and issues that involve science;
2) As a result of the Research Project, I am better able to make connections between science and my everyday life;
3) As a result of the Research Project, I gained useful practice in interpreting figures, charts, and maps;
4) As a result of the Research Project, I gained useful practice in making observations about the natural world and interpreting them.

The results of the survey are shown in Figure B. The vast majority of the students indicating Agree or Strongly Agree with all four of the survey questions. Written comments on the survey about the research project were overwhelmingly positive. Several students indicated that they found the project very confusing at first, but in the end they had a much better appreciation of how research is conducted in relation to environmental problems.

Embedded questions on the final exams have been developed to assess the impact of the project on content knowledge. A scoring rubric was developed for the questions, and students were scored as to whether they had: 1) met the content goal of the question, 2) had partially met the goal, or 3) did not meet the goal. Data for the GEOS 102/103 sequence is shown in Table A. A slight improvement in understanding of seismic waves and plate tectonics occurred since the introduction of the semester long projects.

Figure B:

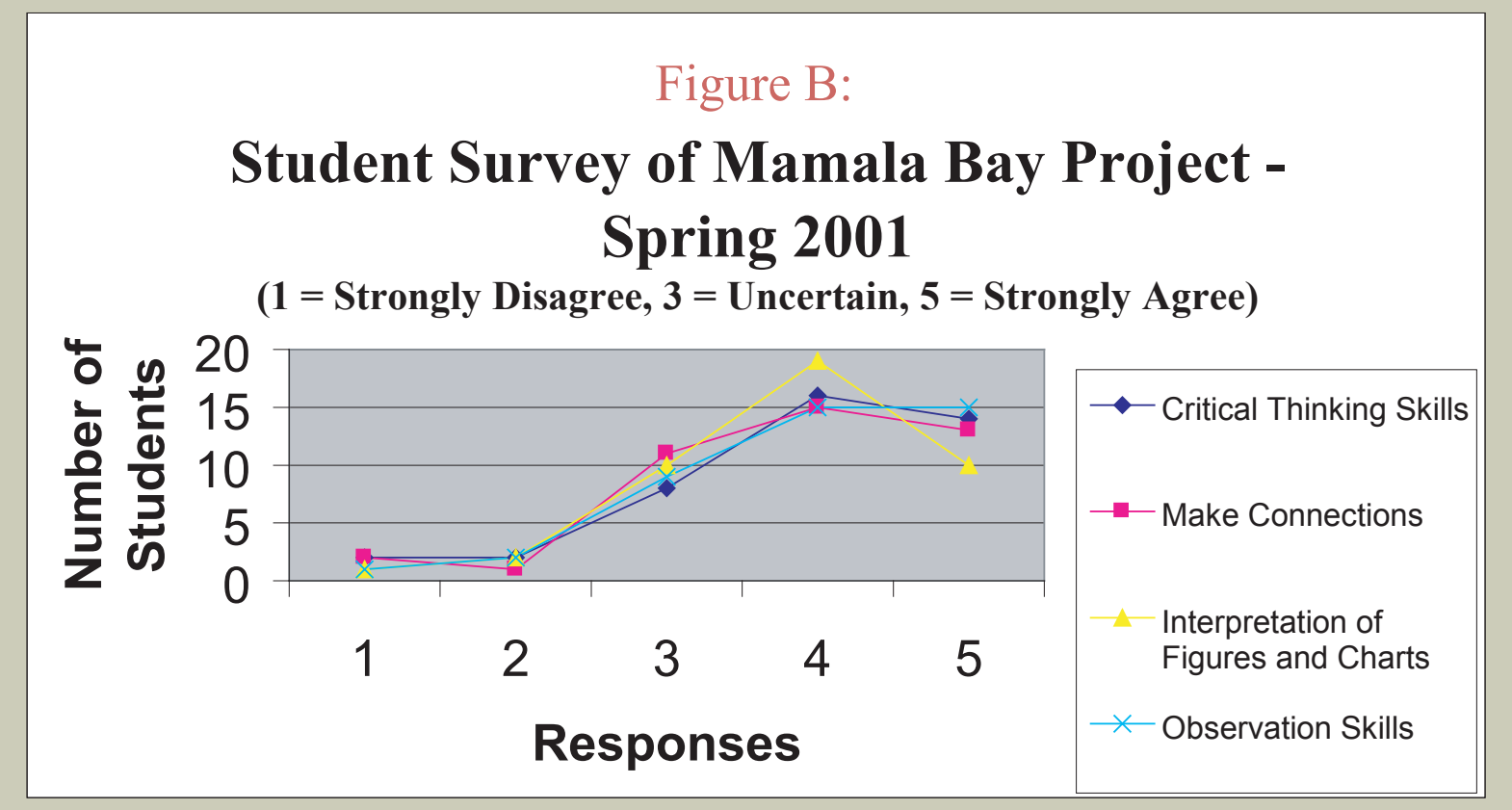

Table A: Embedded Question Learning Objective GEOS 102/103	Percentage of Students Meeting the Goal		Percentage of Students Partially Meeting the Goal		Percentage of Students Not Meeting the Goal	
	Fall 2001	Fall 2002	Fall 2001	Fall 2002	Fall 2001	Fall 2002
Describe the nature of seismic waves and how they are measured.	52.6	65.6	42.1	15.6	26.3	18.8
Describe the three major types of plate boundaries, and give specific geographic examples of each.	52.6	53.5	21	43.5	26.3	19.4

Conclusions:

The dependence on web-based resources does lead to some complications. There were a number of instances in which the URL of a web-site either changed, the contents of a site were radically edited, or the site was permanently removed from the web. Students quickly learn to copy data sets or images so they would have access to them. Downloading capability from home computers limited off-campus work. The College's Library and computer labs were accessible and allowed access to programs and databases.

Students' background in Math/Statistics and familiarity with the various computer applications improves the quality of presentation.

Student responses on the survey, from student evaluations and anecdotal comments, all indicate that the research projects were useful in helping students become engaged with "real-world" problems in the earth sciences. These types of exercises provided a more inquiry-based approach to introducing new topics in a traditional lecture and laboratory course.

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