*Earthquake Engineering, Tenth World Conference © 1992 Balkema, Rotterdam. ISBN 90 5410 060 5*

# Investigating teacher knowledge of earthquakes

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ABSTRACT: Some teachers are uncomfortable and unprepared to teach science. As interest in earthquake education increases, it cannot be presumed that teachers have an understanding of tectonic processes and earthquake mitigation processes. Therefore, the purpose of this study was to determine the earthquake knowledge of 45 educators with a 60-item true-false instrument. Scores ranged from 43-60, with a mean of 52.5 (standard deviation 4.27) and showed a need for educators to receive more explicit information in a number of areas including the role of energy in tectonic processes, the cause of an earthquake, and appropriate action during earthquakes. Results also showed that teachers, like children, can simultaneously hold correct and incorrect beliefs. Suggestions for teacher in-service training, the role of engineers in the education process, and future research are provided.

## 1 INTRODUCTION

In science, as in other areas of instruction, early learning lays the foundation upon which subsequent knowledge is built. Scientific concepts are neither simple nor simply acquired; learning does not occur in one step (Pines & West, 1986). Accurate and effective early instruction is necessary and has long-term implications, as evidenced by the small numbers of American students who go on to study science and engineering. Unfortunately, science instruction is allotted a small amount of time in elementary classrooms in the United States, less than 30 minutes a day on average (Davis, 1990). Many teachers are uncomfortable and unprepared to teach science (Dobey & Schafer, 1984; Smith, 1984; Williams, 1990) and as a result, the basic groundwork provided at elementary and secondary levels is inadequate for advanced work at the university level (Williams, 1990).

One topic covered in science education is the occurrence of natural phenomena, such as earthquakes, and the appropriate precautions to be taken should one occur. Previous research has found that children can confuse earthquakes and volcanoes (Bezzi, 1989; Ross & Shuell, 1989) and that they can hold beliefs about other geologic phenomena that contain misconceptions (Ault, 1984). It has also revealed that some adults hold beliefs about earthquakes that scientists would consider misconceptions. For example, Turner, Nigg, and Paz (1986) interviewed a representative sample of 1,450 adults in southern California and found that many believed in such predictors as "earthquake weather."

As interest in earthquake education increases, it cannot be presumed that teachers have an understanding of tectonic processes and earthquake mitigation procedures. The purpose of this study, then, was to determine the earthquake knowledge of educators who would be instructing children and identify areas where there may be a need for more information.

## 2 METHOD

Forty-five elementary and secondary school educators from an area of moderate to high seismic risk participated in this study. Some of the educators were currently not teaching.

The Earthquake Information Test, a 60-item true-false instrument (Ross & Shuell, 1990), was used to determine teacher knowledge and misconceptions. This instrument consisted of scientifically accurate phrases, generated from a nationally recognized curriculum, *Earthquakes: A Teacher's Package for Grades K-6/FEMA 159* (Callister, Coplestone, Consuegra, Stroud, & Yasso, 1988) and a geologist at the National Center for Earthquake Engineering Research. These phrases were interspersed with misconceptions previously expressed by students in individual interviews (Ross & Shuell, 1989). Hoz (1983) noted that the conventional measure of correctness of responses is not the only measure to be considered when identifying misconceptions. The nature and type of errors is also important. As a result, this test was designed to provide both a measure of correctness and an indication of misconceptions.

The test consisted of two parts. Part 1 was used to gather information about the respondent. Part 2 was divided into four sections: the definition of an earthquake, the cause of an earthquake, what occurs during an earthquake, and appropriate action that should be taken in the event of an earthquake. There were 11 items in the first section, 15 in the second, 16 in the third, and 18 in the fourth. True and false items were included in each of these four sections. Figure 1 provides some questions from the first section of the test.

An earthquake is:

| | | |
|---|---|---|
| T | F | A shaking of the earth. |
| T | F | A release of energy stored in rocks. |
| T | F | A volcano. |
| T | F | An explosion. |

Figure 1. Sample Questions.

The test was administered to the educators by an earthquake education instructor, prior to their receiving an earthquake education course.

The Kuder-Richardson Formula 20 (K.R. 20) was used to determine the reliability of the evaluation tool, based on internal consistency. Estimates of reliability based on the average correlation among items within a test are said to concern internal consistency, which measures how much the domain holds together (Nunnally, 1978). An item analysis was also done. Questions where respondents had indicated both true and false as the correct answer were eliminated.

## 3 RESULTS

The internal consistency of the Earthquake Information Test, as measured by the K.R. 20, was .70 and the standard error was 2.33. There was a mean of 52.5 (s.d. 4.27). Scores ranged from 43 to 60 (the maximum score), with the mode being 55. The highest and lowest scores were both achieved by one person.

The most difficult question on the test (difficulty of .49) related to the cause of an earthquake, with 51% of the educators marking the response "layers of the earth fighting," true. This question came from an analogy previously verbalized by a group of fourth graders in interviews after they had received earthquake education instruction. As one student described it, "The crust gets mad at the mantle and they start fighting." The "true" response given by over half the educators indicates some confusion about the use of this analogy.

On this test, the majority of respondents correctly marked as true that earthquakes are caused by the release of built up pressure, movement of crustal plates, tectonic plate movement, and energy release at zones of weakness. However, some educators also marked "true" that an earthquake is caused by the earth's core moving to the surface, nuclear testing, and atmospheric conditions. Figure 2 shows a summary of responses to the cause of an earthquake.

The core as a cause of earthquakes was seen in the responses of students in fourth to sixth grade in a preliminary study (Ross & Shuell, 1989) and in a previous administration of the same test to 194 students in fourth, fifth, and sixth grades (Ross & Shuell, 1990) where almost an identical percentage of students marked this question true; 30% compared with 31%. Also in the current study, approximately one fifth of the respondents marked "true" that during an earthquake the core moves toward the crust and hits it, and the core releases air. Both of these questions were particularly good discriminators between high and low scoring groups with point biserials of .57 and .50 respectively.

As can be seen in Figure 2, 24% also judged the "the release of energy at zones of weakness in the Earth" as a cause of earthquakes to be false. In a related question, the definition of an earthquake as "release of energy stored in rocks," was marked false by 45% of the educators. Understanding of the relationship of energy in tectonic processes was previously found to be difficult for students in grades 4-6 (Ross & Shuell, 1990).

In the earthquake response section of the test, a number of questions proved difficult for respondents: an answer which said that, in an earthquake, a person should go to the first floor if in a tall building was marked true by 31% of the educators while "going into the storm cellar" was marked true by 23%. All of the responses are shown in Figure 3.

## 4 CONCLUSIONS

The results of this study should be interpreted cautiously because the data are based on the answers of one group of educators in one geographic area. However, even with these restrictions, results of this administration of the Earthquake Information Test raise some interesting questions. The first relates to the use of analogies, as seen by the response of the educators to the definition of an earthquake as "layers of the earth fighting."

To simplify complex earthquake education concepts for younger students, it may be necessary to rely more on analogies. Therefore, it is important to know to what extent analogies can be a useful instructional tool and whether students and their teachers will correctly infer the relationship between the analogy and the concept. If an analogy is taught as a basic fact it will not encourage transfer to pertinent problem situations and could inadvertently reinforce misconceptions, in this case an anthropomorphic view of natural events. In addition to examining the use of analogies as instructional tools, there is also a need for appropriate analogies to be developed.

The placement and relationship of the core to the tectonic process appeared to be elusive to some of the educators. Responses seem to indicate a lack of understanding of the composition of the earth and the spatial relationships that are involved. Marking as true questions involving movement of the core to the crust or surface could also be indicative of confusion with convection currents. If students are to get accurate information in this regard, we must ensure that educators understand this.

The relationship of energy in tectonic processes seemed difficult for some educators to comprehend. Understanding the concept of energy has been shown to be difficult for other groups as well, including physics undergraduates (Viennot, 1979) and high school students after a unit on energy (Solomon, 1983). There is a need to examine how the relationship of energy to earthquake generating mechanisms is being taught.

The Earthquake Information Test also revealed that, as had been found previously with student testings, the educators could correctly mark scientifically acceptable viewpoints while simultaneously marking as true viewpoints that would be considered incompatible. This is consistent with the research of Turner, Nigg, and Paz (1986) who found after interviewing adults that acceptance of a scientific explanation of earthquakes did not necessarily mean rejecting all explanations that were incompatible with current scientific viewpoints.

There is a need for teachers to be given more complete information about earthquake generating mechanisms and the appropriate preparedness actions to mitigate the effects of an earthquake. Teachers play the central role in communicating earthquake facts to their students and can serve as the focus of educational intervention activities designed to enhance and supplement student learning in such areas as earthquake education. Educational intervention programs, however, also require support and commitment from members of the community, the academy, and the practicing sector. Some of the factors which help science-math intervention programs succeed provide excellent opportunities for earthquake engineers to play a role. They include collaboration with pre-college groups through professional society outreach programs, such as those organized by the ASCE; visibility on an individual level as a role model in professional engineering; and contribution of materials, hands-on activities (such as seismic design projects), and other instructional resources that can assist teachers in the presentation of fundamental earthquake concepts (Nurturing Science and Engineering Talent, 1987).

Engineers can further contribute to the educational pipeline by promoting increased opportunities for science and engineering undergraduates, by participating in internship and mentoring programs for both students and teachers from pre-college through graduate level, and by getting involved in curricular issues - not only for potential engineers but for future educators. In these ways, engineers assist teachers and students. In the short-term engineers provide access to interesting and accurate earthquake material; in the long term they promote improvements in the science and mathematics educational environment.

To conclude, the educators in this study had some knowledge about earthquakes and appropriate response, although there may be a need for more explicit information in a number of areas: the role of energy and convection currents in tectonic processes, the cause of an earthquake, and appropriate action during earthquakes in different environments. Further testing of teachers is needed to identify areas of difficulty or insufficient knowledge. With this information, earthquake education and mitigation professionals can address knowledge gaps and provide effective support materials and training.

This is particularly necessary as today's teachers are required to provide instruction on an increasing number of science-related issues, such as environmental, health, natural disaster and technological topics, for which they received inadequate or no college training. The earthquake community is obliged to assist our children's educators so they can deliver accurate messages about earthquake science and mitigation. The benefits are a better prepared and educated public and a source of potential earthquake mitigation professionals for the future.

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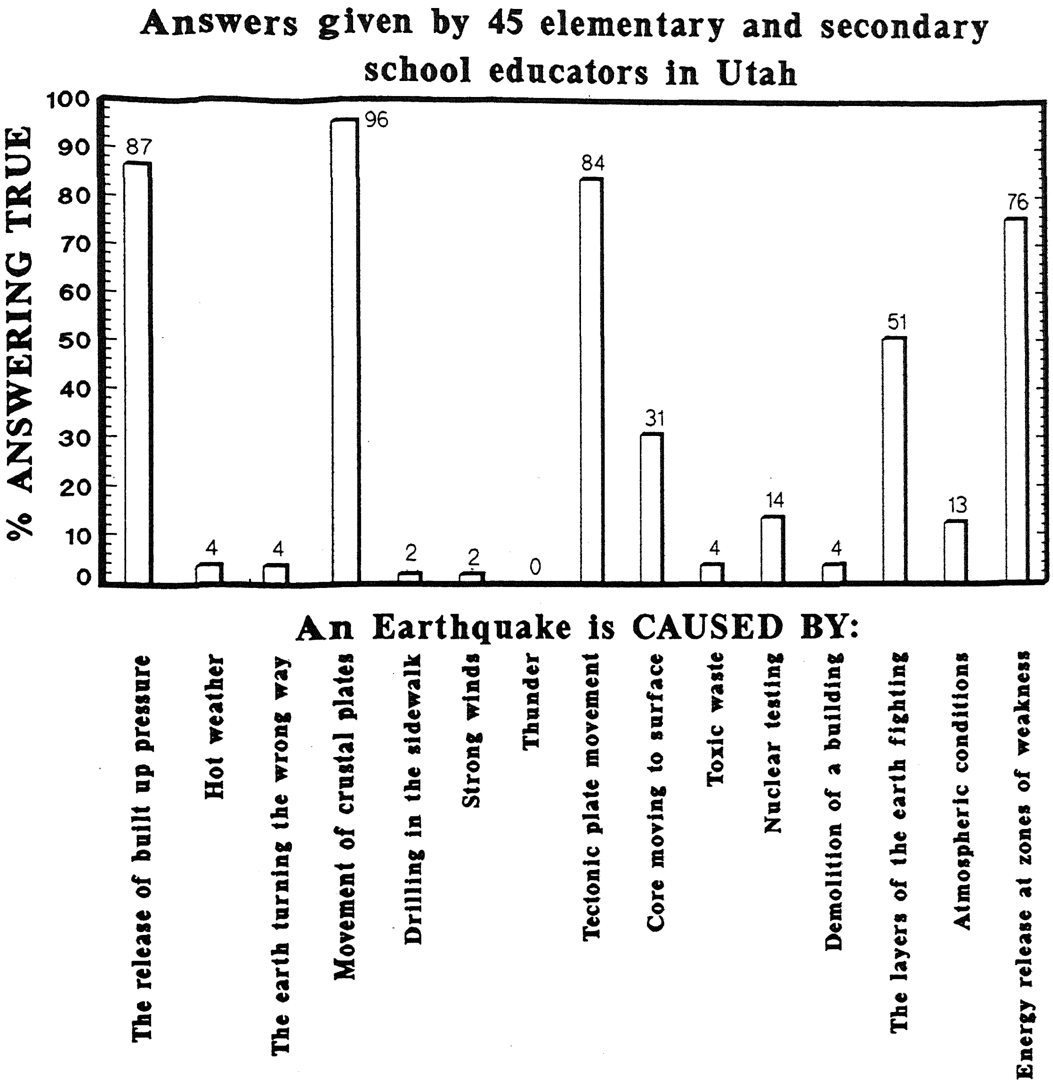


Figure 2. Causes of an earthquake.

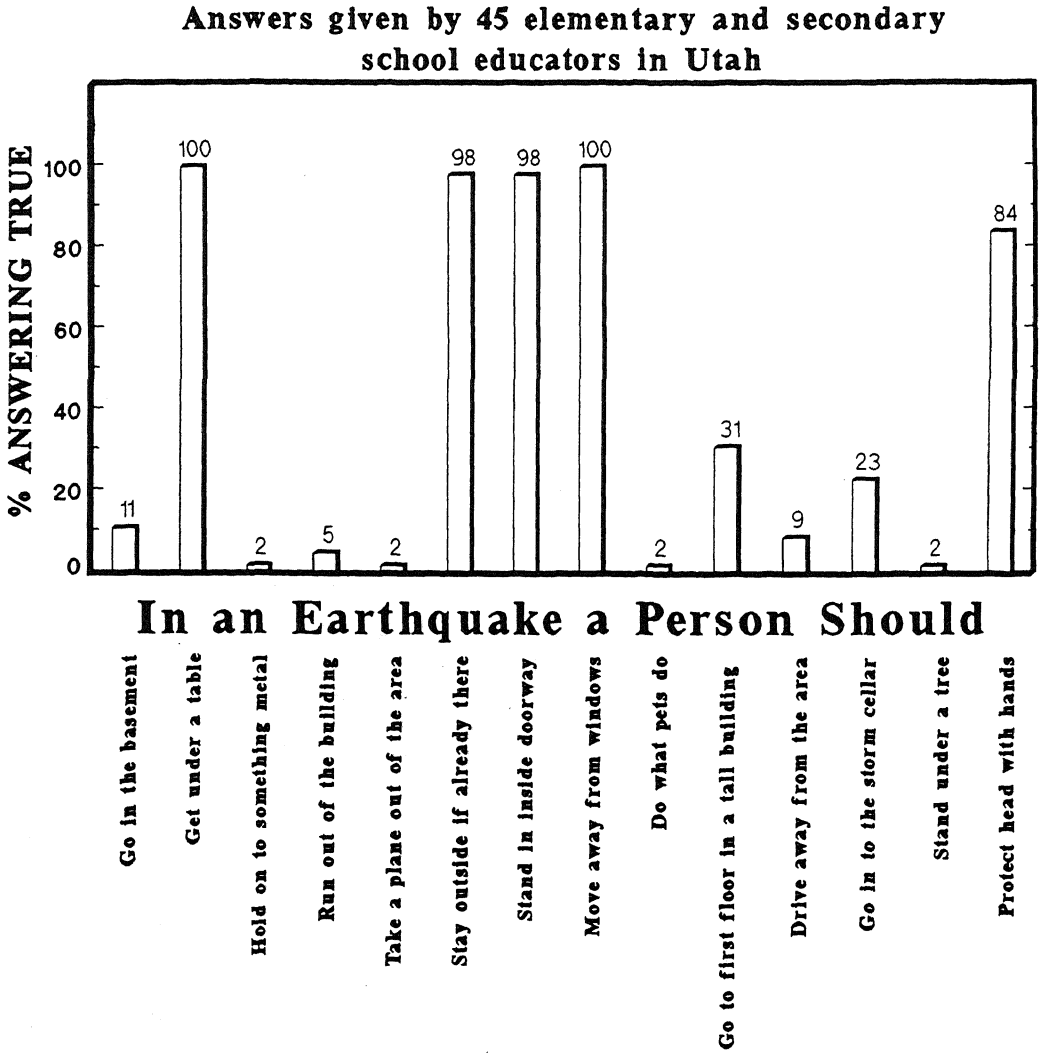


Figure 3. Response during an earthquake.