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RESEARCH REPORT

# Ideas about earthquakes after experiencing a natural disaster in Taiwan: An analysis of students' worldviews

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On September 21st, 1999, the central part of Taiwan suffered an earthquake which was 7.3 on the Richter scale. This disaster provided a unique and rare opportunity to study students' worldviews. Science educators have proposed that students' worldviews influence their ways of interpreting natural phenomena and then impose an effect on conceptual development in science. The objective of this study was to explore students' worldviews as revealed by their ideas about the causality of earthquakes after experiencing the natural disaster. In Taiwan's socio-cultural milieu, there are some indigenous worldviews about earthquakes including the perspectives of supernatural forces and myths. Through tracking the ideas of 60 fifth graders and sixth graders for eight months, this study showed that students tended to employ the following three major approaches to resolve the incongruence between indigenous worldviews and scientific worldviews. First, they may try to accept the scientific ideas and to abandon their original worldviews. Second, they may try to grasp the scientific views and at the same time try to keep the indigenous worldviews unchanged. Many students held a scientific/myths dual perspective about the causes of earthquakes. Finally, they may retain their original worldview and try to ignore the scientific worldview. This paper finally suggests that science educators need to integrate socio-cultural aspects of science and of learning science into science education research and practice.

## Introduction

People, even infants, always try to construct ways of explaining natural phenomena. However, many do not construct scientifically acceptable views. Hence, in the last two decades, numerous science educators have devoted themselves to investigating students' 'misconceptions' or 'alternative conceptions' (Helm and Novak 1983, Novak 1987, Wandersee *et al*., 1994). Students' misconceptions or alternative conceptions, clearly, have some basis. Sociocultural influences may play an important role in their ideas (Cobern 1998a). Recently, science educators have become aware of the possible effect of student worldviews on their conceptual development in science (Cobern 1993, 1996, Lee 1999). Worldviews are a set of beliefs or assumptions about the basic nature of reality and they are constructed in sociocultural environments (Lee 1999). Therefore, students' worldviews may influence their interpretations of natural phenomena.

Scientific worldviews are based on the tradition of Western science, which is itself a sociocultural product. For instance, Ponting (1991) has illustrated how Christian theology influences Western people's views about the relationships between humans and the natural world and how this had led to the dominance

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of reductionist modes of scientific thinking, i.e., the emphasis on observing parts of the system rather than looking at the whole. However, research has shown that the worldviews held in other cultures often conflict with scientific worldviews which then causes some difficulties with and a reluctance to accept the scientific ideas (e.g., Ogawa 1986, 1989, 1995, Jegede 1995, Cobern 1998b). For instance, some Chinese myths about the moon may inhibit a few Chinese students' acceptance of the idea that the moon is really a planet without any living things. Indigenous worldviews may play a role in the formation of students' alternative conceptions (or misconceptions). Allen and Crawley (1998) have asserted that worldviews shape people's cognitive structures into which they fit new information. If educators do not recognize students' worldviews, they may not be able to change students' alternative conceptions. Moreover, researchers propose that worldviews provide an epistemological standard upon which a person's thinking is based and which then guide his or her conceptual development in science (Cobern 1996, Allen and Crawley 1998). The study of students' worldviews, especially those of non-Western cultures, may provide potential insights about how students construct scientific knowledge and interpret natural phenomena.

Early worldview research in science education usually explored the worldviews held by some non-typical Western people. For example, Allen and Crawley (1998) investigated the worldviews expressed by a group of Kickapoo students in grades 5-9 who lived in south Texas in the USA. Similarly, the study by Kawagley *et al.* (1998) discussed the indigenous worldview of Yupiaq culture. The Yupiaq culture is one of several Alaska Native cultures. A recent study by Lee (1999) used a new way of exploring students' worldviews. Lee (1999) examined children's knowledge about hurricanes after they experienced Hurricane Andrew in South Florida, USA, for she believed that the natural disaster provided a rare and unique opportunity for investigating student worldviews. These students would have to construct their ideas about a natural disaster that had great influence on their lives, and those of their families and the whole community. These ideas could reflect students' original worldviews.

Earthquake is also a natural disaster people may experience. By interviewing a group of fifth graders and sixth graders (11-year olds and 12-year olds) who had experienced a serious earthquake in Taiwan, this study set out to explore students' ideas about the causality of earthquakes. Their worldviews were further analysed based on their ideas about the earthquake. In sum, this study integrated the two major approaches of worldview research in science education reviewed above; the investigation of non-Western people's worldviews, i.e., those of Taiwanese children; and ideas about a natural disaster after it had been experienced (i.e., the earthquake).

## Contextual settings and purposes of the study

On September 21st, 1999, 01:47 a.m., the central part of Taiwan Island suffered an earthquake which was 7.3 on the Richter scale. The epicenter of the earthquake was located around the center of Taiwan Island. Its focus was 3 kilometers below surface. The earthquake killed more than 2000 people, and more than 10,000 people were injured. Nantou and Taichung counties were two areas where the most damage occurred. Like the study conducted by Lee (1999), this natural disaster provided a rare and unique opportunity for investigating student worldviews

in Taiwan. The occurrence of earthquakes is unpredictable, therefore students may be more likely to have diverse interpretative perspectives. There is folklore in China about earthquakes, while, on the other hand, after this earthquake, the students were exposed to scientific views from the public media and their teachers. The contextual setting provided a unique opportunity to investigate how students reconciled indigenous worldviews and scientific views. Students' information sources about the ideas of earthquakes were also explored in this study. In a small longitudinal study, tracking a group of Taiwanese fifth and sixth graders for 8 months, the major research questions of this study were:

- What are students' worldviews as reflected in their ideas about the causality of earthquakes?
- How may students' worldviews change at different stages after experiencing earthquakes?
- What are students' information sources about the causality of earthquakes?

## Method

### *Sample*

The sample was 60 fifth and sixth graders (11-year olds and 12-year olds) from Nantou and Taichung counties where the most damage was experienced. Thirty-two students in the sample were female. These subjects came from seven different elementary schools. They lived in towns near a large city of Central Taiwan and their socioeconomic status was about average.

### *Data sources*

The data analysed in this study were gathered by interviewing the sample subjects. The interviews were conducted individually in a total of four rounds: that is, two weeks, two months, five months, and finally eight months after the earthquake. The interview took about two to five minutes for each interviewee on each occasion. Due to the unexpected absence of some subjects in the later interviews, the number of the sample is 60, 56, 57, and 55 for the four rounds of interviews, respectively. In the final interview, students were asked to reflect upon their 'major' information sources about the causes of earthquakes. It should be noted that immediately after the earthquake, the public media (e.g., radio, newspaper, television) and formal schooling provided scientific information about the causality of earthquakes. The scientific ideas may have interfered their original ideas about the earthquakes.

### *Coding categories of worldviews*

Students' worldviews as reflected by their ideas about the causality of earthquakes were initially classified into one of the following categories:

- Scientific: for example, moving plates of rocks, releasing energy from the mantle.
- Supernatural/spiritual forces: for example, 'some unknown forces, perhaps, coming from ghosts, cause the earthquakes'.

- Myths (including the perspectives of anthropomorphism and animism): for example, 'God is angry'.

However, after examining the students' interview transcripts, it was found that their worldviews were far more complicated than had been originally assumed. For example, students combined ideas from the 'supernatural' and 'myths' categories. Many students mixed ideas of 'scientific' and 'myths' categories. Still others had scientific misconceptions about earthquakes; that is, they tried to frame the causality of the earthquakes in scientific terms, but in a scientifically inaccurate (or unclear) way. For example, a few subjects stated that 'the occurrence of earthquakes comes from a radical change of gravity'. Or, one subject attributed the causes of earthquakes to electromagnetic waves. Hence, a new category, called 'scientific misconception', was proposed. Rare responses were also found; for instance, a few students had mixed ideas of 'supernatural' and 'scientific', and others gave functional explanations from a teleological perspective (e.g., 'the earthquakes want to destroy human beings'). These rare responses were coded into an 'other' category. As a result, the final coding categories of worldviews were as follows:

- Scientific: for example, moving plates of rocks, releasing energy from the mantle.
- Supernatural (including spiritual forces): for example, 'the devil makes the earth shake'.
- Myths (including the perspectives of anthropomorphism and animism): For example, 'the God of the Earth is very angry about what people do to him. He tried to warn people'.
- Scientific/myths: mixed ideas of 'scientific' and 'myths'.
- Supernatural/myths: mixed ideas of 'supernatural' and 'myths'.
- Scientific misconceptions: for instance, 'the occurrence of earthquakes comes from a radical change of gravity'.
- Other: other mixed ideas (e.g., mixed ideas of 'supernatural' and 'scientific'), teleological explanations or no responses.

The coding processes were performed by a university science education professor and one elementary school teacher. They read the whole set of interview transcripts independently and then decided a worldview category for each subject's ideas in each round of the interview. The coding agreement was 0.93 between these two researchers. For the interview data that did not have researchers' agreed categorization, the researchers reviewed the transcripts again and discussed case by case, and then determined a final categorization.

## Results

### *Students' worldviews across the interviews*

Students' worldviews revealed by their ideas about the causality of earthquakes are presented in table 1. Although students may have received scientific information about the causes of earthquakes from teachers and public media within two weeks after experiencing the disaster, many students attributed the causes of earthquakes to supernatural forces (12%), or they used traditional Chinese myths to explain

**Table 1. Students' worldviews reflected in their ideas about the causality of earthquakes.**

| *Worldviews* | *Two weeks after the earthquake* (*n*, #) | *Two months after the earthquake* (*n*, #) | *Five months after the earthquake* (*n*, #) | *Eight months after the earthquake* (*n*, #) |
|---|---|---|---|---|
| Scientific | 8 (13%) | 15 (27%) | 17 (30%) | 15 (27%) |
| Supernatural | 7 (12%) | 4 (7%) | 3 (5%) | 2 (4%) |
| Myths | 10 (17%) | 9 (16%) | 9 (16%) | 7 (13%) |
| Scientific/myths | 12 (20%) | 14 (25%) | 16 (28%) | 16 (29%) |
| Supernatural/myths | 15 (25%) | 9 (16%) | 6 (11%) | 10 (18%) |
| Scientific misconceptions | 2 (3%) | 3 (5%) | 2 (4%) | 2 (4%) |
| Other | 6 (10%) | 2 (4%) | 4 (7%) | 3 (5%) |
| Total | 60 | 56 | 57 | 55 |



earthquakes (17%), and still many of them expressed a worldview which combined supernatural forces and myths (25%). This finding may suggest that students tend to use indigenous worldviews in perceiving a natural disaster immediately after experiencing it. Furthermore, when compared to the results elicited in the first interview, more students had scientific views about earthquakes and fewer students used supernatural forces to explain earthquakes in the last three interviews. However, many students expressed a scientific/myths dual perspective throughout the study. The scientific/myths dual perspective was gradually held by more and more proportion of students as the study progressed (i.e., 20%, 25%, 28% and 29% respectively).

The worldviews constructed in the socio-cultural milieu of Taiwan may not be similar to the scientific worldviews built on the tradition of Western science. This study suggested that students tended to employ the following three major approaches to resolve the incongruence between indigenous worldviews and scientific worldviews. First, they may try to accept the scientific ideas and to reject their original worldviews. Second, they may try to acquire the scientific views (perhaps, through memorization), and at the same time, try to keep the indigenous worldviews unchanged. Hence, they hold a dual (i.e., scientific/myths) perspective. Finally, they retain their original worldviews and try to ignore the scientific worldviews. Therefore, many students in the final interview still stated either a 'myths', 'supernatural' or 'myths/supernatural' (a total of 35%) worldview. Figure 1 shows the proportion of students who utilized these three strategies respectively. Based on the research data of the final three interviews, each of these strategies was employed by about one third of students in the sample.

Students' ways of resolving the discrepancy between the scientific worldviews and indigenous worldviews are similar to those of resolving the conflict between the scientific ideas and their misconceptions as shown in the research literature. The first strategy described earlier is similar to the 'unified scientific outcome' in which students overcome their misconceptions and then accept the scientific ideas. The second strategy is similar to 'two perspectives' outcome in which students accept the scientific ideas but keep their misconceptions intact. The final strategy is similar to 'undisturbed' outcome in which students retain their misconceptions

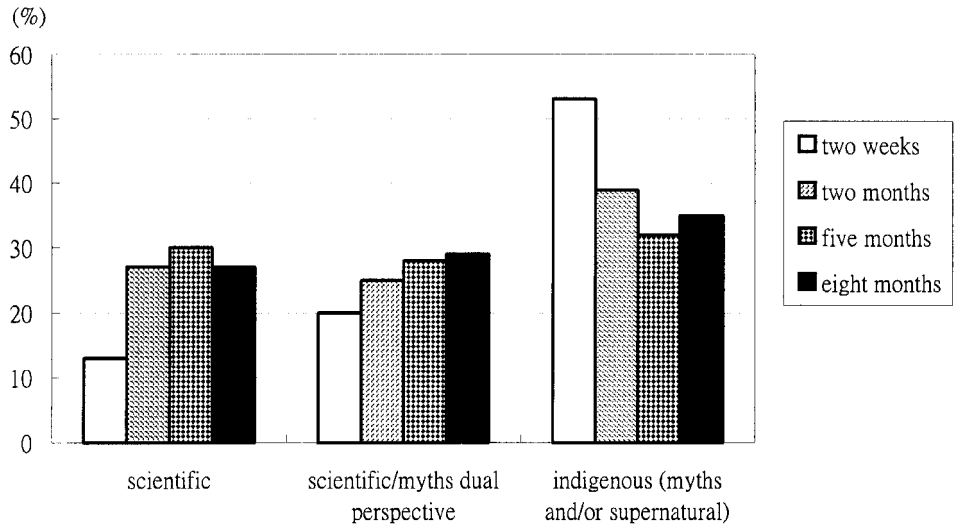


**Figure 1. Students' strategies of resolving the discrepancy between scientific and indigenous worldviews.**



and ignore the scientific ideas (Gilbert *et al.* 1982). Tsai (1999a, 2000a) has also argued that science students may encounter various sorts of incongruence between their existing views and science teachers' perspectives, including the incongruence of content knowledge, methodology, ontology, epistemology, pedagogy, and knowledge representation in science. This study may further imply that students may employ either one of the three major approaches summarized above whenever encountering new information that is different from their existing perspectives.

### *Students' information sources about earthquakes*

In the final interview, students were asked to give one major information source of their ideas about earthquakes. As expected, teachers, parents (or mature family members) and public media (newspaper, television) were major information sources. Although many students could select only one major information source, some of them stated that their ideas came from 'multiple major' sources, and could not differentiate which one was the principal source. As a result, 15 students identified 'teachers' as the major information source, 10 students identified 'parents', 13 students identified 'public media', while 14 students believe in 'multiple sources'. That is, students' reflections on major information sources of 'teachers', 'parents', 'public media', and 'multiple sources' counted for 52 among the 55 interviewed subjects. The other three subjects identified some science-related books and encyclopedias, or friends as their major information sources about earthquakes. A simple analysis about students' major information sources and their ideas about earthquakes elicited in the final interview is presented in table 2.

Because of the limited sample size, no statistical test could be performed. However, the results of table 2 likely suggest that a higher percentage of using 'teachers' and 'multiple' sources held scientific views. This implies that teachers

**Table 2. An analysis of student information sources and worldviews elicited in the final interview ($n = 52$)*.**

| *Information sources* | *Worldviews of earthquakes* | *N* | *Total* |
|---|---|---|---|
| Teachers | Scientific | 6 | 15 |
| | Supernatural | 0 | |
| | Myths | 1 | |
| | Scientific/myths | 3 | |
| | Supernatural/myths | 3 | |
| | Scientific misconceptions | 1 | |
| | Other | 1 | |
| Parents (or mature family members) | Scientific | 1 | 10 |
| | Supernatural | 1 | |
| | Myths | 2 | |
| | Scientific/myths | 4 | |
| | Supernatural/myths | 2 | |
| | Scientific misconceptions | 0 | |
| | Other | 0 | |
| Public media | Scientific | 2 | 13 |
| | Supernatural | 0 | |
| | Myths | 3 | |
| | Scientific/myths | 5 | |
| | Supernatural/myths | 3 | |
| | Scientific misconceptions | 0 | |
| | Other | 0 | |
| Multiple sources | Scientific | 5 | 14 |
| | Supernatural | 1 | |
| | Myths | 1 | |
| | Scientific/myths | 3 | |
| | Supernatural/myths | 2 | |
| | Scientific misconceptions | 1 | |
| | Other | 1 | |

*Note*: * Three subjects did not be included in this analysis, as their information sources did not fit the categories shown in this table.



and a 'triangulation' of multiple information sources may facilitate students' conceptualization of the scientific worldview. However, students with the information sources of 'parents' and 'public media' had more 'myths' and 'scientific/myths' worldviews. The television news in Taiwan often uses a title of 'The Bull of the Earth Turns His Body' to describe the occurrence of earthquakes. The Bull of the Earth, in Chinese myth, is similar to the God of the Earth. This may lead students to view earthquakes in the 'myths' perspective. The interplay between students' information sources and their worldviews is a challenging research question that clearly needs much more efforts to clarify the complicated interaction.

## Implications for further research

Several students in this study believed in supernatural forces that caused earthquakes. It is not uncommon for some Taiwanese adults to take unknown medicines from temples to cure their diseases. This implies that some people in Taiwan still rely solely on supernatural forces to explain their lives. This study showed some

evidence that students struggled to reconcile their indigenous worldviews and the scientific worldview. More research is necessary to investigate the diverse experiences of students coping with or struggling with their worldviews within the culture of science. Another interesting research question may be to compare Taiwanese students' worldviews about earthquakes in an earthquake area with those of non-earthquake area. This comparison can provide some insights into how the lived experiences of a natural disaster may impose an effect upon students' worldviews.

Students' worldviews, indicating the ways of knowing nature, may be related to their scientific epistemological beliefs. Recent research has revealed that students' scientific epistemological beliefs have some relationships to their knowledge structures, learning orientations and preferences in science (Tsai 1998a, 1998b, 1999b, 1999c, 2000b). Science educators are encouraged to explore the connections between student worldviews and scientific epistemological beliefs, and how these views and beliefs together influence students' knowledge acquisition in science. Cobern's paper (1998b) suggested a way of exploring people's scientific epistemological beliefs. Researchers can ask students to describe the relationships between 'the natural world', 'science', and 'the social world'. These relationships can represent students' epistemological views of science from a 'strict empiricist view of science' (e.g., science and the social world are totally isolated) to a 'radical social constructivist view' (e.g., science is almost wholly a social construction, little affected by the natural world).

Research into worldviews and epistemological beliefs suggests that 'scientific pluralism' should be reflected in the teaching of school science and the nature of science, especially in the science education of non-Western countries. That is, the implementation of science instruction and curriculum needs to have a socio-cultural sensitivity (Cobern 1998b). By recognizing various worldviews or perspectives of science, students can appreciate the rich diversity and local practices of scientific endeavor (Rudolph 2000). Jegede (1997) and Jegede and Aikenhead (1999) also proposed cross-cultural Science, Technology and Society (STS) curricula for non-Western countries that integrated indigenous commonsense knowledge, Western knowledge of science, and indigenous and Western technology. Moreover, some educators believe that the practice of constructivism could be largely enhanced if science is viewed as a socio-cultural activity (Milne and Taylor 1998). Science educators are encouraged to integrate socio-cultural aspects of science and of learning science into science education research and practice.



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