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Native American students' understandings of geologic time scale: 4-8th grade students' understandings of earth's geologic history

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Abstract

Geologic time scales is very important concept for understanding earth system events such as global climate change. However, understanding of geologic time scale in a relationship with human history is very difficult because of relatively short period of human existence in earth history. This study shows that Native American elementary students understand geological and historical event based on relative order of earth history. They understand Earth's geological event as a sequential series. More importantly, they understand human history based on their own culture and history.

Keywords: Geologic time scale, absolute time, relative time;

1. Introduction

Under the increasing pressure of public concerns about environmental issues such as global warming and destruction of ecosystems, understandings of earth as a system have become essential for a scientifically literate citizenry. Understanding earth as an integrated system requires not only correct conceptions about earth science but also a holistic view to see how systems and systems' elements interact with other parts of our planet. The concept of time scales is repeatedly mentioned in the earth system science literature. Understandings of geologic time scale in earth history is one of important sub-concepts to understand time scale of earth system such as time scale of global climate change in earth geologic history. The understandings of geologic time scale of fundamental to deal with important climate change debate about whether the global climate change is due to human or natural cycle.

Students' understandings of geologic time scales have been studies by earth science educators (e.g. Dahl, Anderson, & Libarkin, 2005; Libarkin, Anderson, & Science, 2005; Libarkin, Kurdzie, & Anderson, 2007; Trend, 2000, 2001). It is also studies by science education researchers alongside with other earth science concepts (Trend, 1998). They all found that students lack of understandings of absolute time of earth geologic event. Students were also could not put the earth geologic event in correct relative order (Trend, 2001; Libarkin et al., 2007; Schoon, 1992). Unfortunately, most of the researchers in the literature argues that student's geologic time understandings is not significantly important than any other concepts in earth science. Compare to other researchers, Trend (1998) suggested that the concept of geologic time scale (or the concept of deep time) is "unique in providing the

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fundamental framework into which geological events and other phenomena can be located" (p.976).This study presents an out-of-school lesson module designed for Native American students (Ojibwa), using a topic of global climate change using tree ring analysis. Based on the implementation of the module at an American Indian reservation during a summer program, this study explores how students understand geologic events in both relative ordering and absolute time (chronology) of earth geologic event. More importantly, this study explores the student's understandings of human history and its relation with geologic time scales understandings. The specific research questions for this study are: 1) what are the Native American students' understandings of geologic time scale in both relative order and absolute time? And 2) How do the students' understandings of human history is related to their understandings of geologic time scale?

2. Methodology

2.1. Context

The Tree Ring and Geologic Time lesson was designed to improve students' understandings of using proxy data for reconstructing climate conditions (global temperature change and precipitation) and understandings of the concept of geologic time in earth history. The main task for the students was "relative ordering of global geological events on earth history line". Based on the literature review of students' understandings of geologic time scale, we found that upper elementary students have a general awareness of major events of earth geologic history but do not understand a clear chronology (Trend, 1998). They also categorize the earth's geologic event into two distinct time category such as the extremely ancient and less ancient" (Trend, 1998). Because our purpose is to improve students' understandings of geologic time scales in relation with global climate change, we designed our lesson as two different activities; 1) understanding earth geologic event in entire earth history time scale and 2) understanding relatively recent geologic event (last 1,000 years). In the first activity, we prepared different earth historical event cards and ask the students put the card in earth history line, which is 4.5m machine paper (1mm represents 1 million years). The geologic even cards include important earth's geologic events ;End of last ice age, End of Dinosaurs, First continent, First photosynthesis, First plant, Modern Human, etc. In the second activity, students were asked to make a graph using real climate data (precipitation data) and Tree ring chronology data from a place near the reservation. Then we put the graph on 10m paper, in which 1cm represents 1year). The second lessons also included putting important human events in last 1000 years on the 10m paper. The human event included historic event for the Native students (Ojibwa) history.

The lesson was delivered during a summer program as a part of the "Reach for the Sky (RFTS)" program, an NSF ITEST funded summer and after school program for American Indian youth at *White Earth* American Indian reservation in Minnesota during June 2011.

2.2. Participants

Fifty-six, 4th to 8th grade American Indian students participated in the Tree Ring and Geologic Time lesson for five days, one and half hour per day. Students were grouped based on their grades they finished and worked cooperatively to solve the task. The data for this study was from forty three students (15 groups) who submitted their journal entry and answered the questions about geologic time scales. About half of the participant was male.

2.3. Data Collection

The data for this study came from tree main sources: 1) students' worksheets during the lessons – five worksheets were developed focusing on each lesson's purpose, and the students were asked to draw and explain about their understandings of geologic time scale; 2) students' group work of making geologic time line on the machine paper using the given earth geologic event cards; 3) classroom observations and field notes– students discussions and their group working were described by a researcher, audio, and photo images were also collected.

2.4. Data Analysis

Because of the qualitative and interpretive nature of the task, we use inductive approach for analyzing the data. That is, as Patton (2002) described, "instead of searching for predetermined patterns, themes were allowed to emerge from the data as the authors constructed meaning from students' responses" on the worksheets. First, we read the data then tried to find common patterns from the data and developed core concepts about students' understandings of geologic time scale. Finally, we were looking for main themes around the core concepts to answer our research questions. Two researchers participated in the data analysis process in order to enhance the authenticity of the interpretations and the credibility of the findings (Patton, 2002).

3. Findings

3.1. The Native American students' understandings of geologic time scale in both relative order and absolute time

Most of the students put the earth geologic events in three distinctive time zones; near the earth beginning (approximately one fourth of the entire earth history), near the present (approximately one fourth of the entire earth history), and between these two. In the first time zone, most of students put the earth events that are more related to the formation of global earth environment for living things such as oxygen rich atmosphere, 1stcontinent, and photosynthesis. Especially most of the students (10/15 groups) put formation of the moon at the very beginning of the earth history and the oxygen rich atmosphere was followed by that. They had misconceptions of the order of the event of photosynthesis and first plant (See Figure 3). They thought that photosynthesis happened after the earth environment has oxygen rich atmosphere. These events is put together right after the oxygen rich atmosphere and 1stcontinent and breaking up of Pangaea were appeared similar time zone with these event. (See Table 1)

Interestingly, 10 of 15 groups of students put first continents right after breaking up of Pangaea (See Table 2). In the second time zone, most of students put the earth event that is related to the living things became extinct such as dinosaur and 1st land animal. Most of the students put extinction of dinosaur after 1st plant and before 1st land animals (See Table 2). End of last ice age were also scattered around the second time zone but most of the students (12/15 groups) put the end of last ice age after dinosaur extinction (See Figure 2). The last time zone (relatively recent) includes events related to human and mammals. For example most of the students put dogs and bears just before modern human. In summary, students put the earth event in a relative order based on their understandings of Earth history and they do not have understandings of absolute time of these events.

3.2. The relationships between the Native American students' understandings of human history and geologic time scale

The students put human related history at the last time zone (close to present) but they did not consider absolute time related to the event. For example "modern human" were scattered in the last three fifth part of the earth history but more of them were after "dinosaur extinction" The students put the event in an order based on their understandings of relative time of the event such as "modern man – agriculture start – Columbus arrive in America" (See Table 1)

Interestingly, 6 groups of students put "agriculture starts" after "Columbus arrives in America". They thought agriculture started after European came in America because of their own culture and history of harvesting wild rice from lakes around their reservation. (see Figure 1)

This study shows that student's understandings of earth geologic event is based on relative order of earth history that is a series of several events on earth such as formation of the environment for living things, dinosaur extinction, last ice age, and human history. More important, they understand human history based on their own culture and history.

Table 1. Individual students' understandings of relative geological time scale

Title	Number of Students	Mean (Relative order)	Mode	SD	Final Rank
Formation of the moon	43	2.4	1	2.03	1
Dinosaur	43	2.74	2	1.42	2
First Flower	43	4.35	3	0.71	3
First Photosynthesis	39	4.54	2	2.84	4
First Mammal	43	5.23	6	1.81	5
First Bird	43	5.44	5	0	6
Ice Age	43	5.67	8	3.54	7
End of Dinosaur	14	6.64	6	2.02	8
Human appeared	40	7.05	7	2.25	9
End of Ice Age	40	8.27	9	1.43	10

Table 2. Students groups' understandings of absolute geologic time scale

Title	Number of Groups	Mean (Absolute time:0.1 billion)	Mode	SD	Final Rank
Formation of the moon	15	1.6	1	0.99	1
Oxygen Rich Atmosphere	15	2.46	2	1.64	2
First Plant	15	7.73	8	4.32	3
Development of Photosynthesis	15	8	5-6	5.62	4
First Snow Ball Earth	15	12.13	19	6.45	5
First Continent	15	12.33	5	9.68	6
Break up of Pangaea	15	13.4	9	10.75	7
Pr/Tr extinction	12	14.7	7	10.42	8
Extinction of Dinosaur	15	15.06	12	7.59	9
First Animal on Land	14	15.4	9-12	9.59	10
First vertebrate Animal	15	17.46	13-17	9.79	11
Cambrian Explosion	12	17.75	X	10.39	12
End of First Ice Age	15	20	13	10.54	13
Dogs and Bears Appeared	15	27.6	23	9.35	14
Agriculture Started	15	30.13	23-39	10.22	15
7 Fires Prophecy	15	31	39	8.59	16
Modern Man	15	31.13	33	10.78	17
Columbus Arrived	15	34.67	41	7.14	18
Anishinabe Nations	14	36.85	45	12.56	19

4. Figures

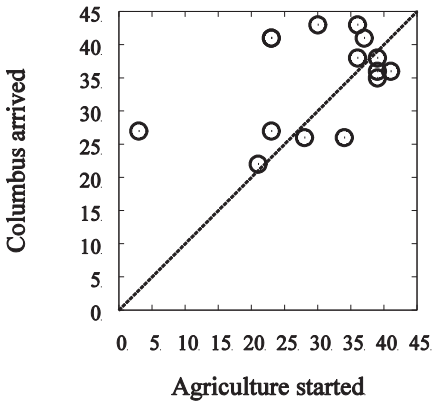

Figure 1. Students' understandings of the order of two historic events (Columbus Arrived vs. Agriculture Started)

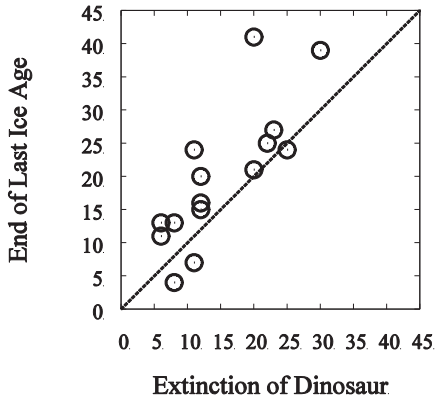

Figure 2. Students' understandings of the order of two historic events (Extinction of Dinosaur vs. End of Last Ice Age)

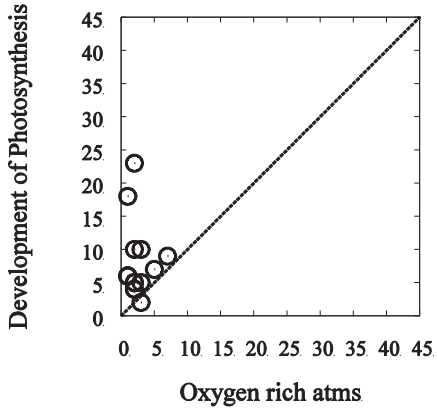

Figure 3. Students' understandings of the order of two historic events (Oxygen rich atmosphere vs. First photosynthesis)

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