Which conceptions do college students hold about changes to earth and life on earth over time?

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Structure

The need of interdisicplinary research!

- A full understanding of scientific concepts requires interdisciplinary teaching approaches (Hicks, Fitzsimmons, & Polunin, 2010; Begg et al., 2014).
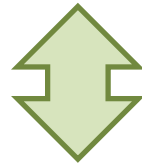
- Science education research is mostly focused within the discipline.
- There has been a lot of research on alternative conceptions about plate tectonics (e.g. Conrad, 2015; Dolphin & Benoit, 2016) and evolution (e.g. FENNER, 2013)
- No study considers these concepts in an interdisciplinary way.

A Study about students` ideas of Co-Evolution of Earth Systems and Life on Earth

- This Study investigated student`s conception of geological **and** biological phenomena
- Students' ideas about co-evolution of earth systems and life on earth were explored by an open-ended survey
- United States and German college students were included in this study
- In both school systems Evolution and Plate Tectonics are taught separately in different subjects although interdisciplinary teaching could promote a better understanding

Research Questions

1. In what ways do students conceptualize large-scale changes to Earth's biology, continental positions, and size over long geologic time?

2. What relationships, if any, exist between student paradigms about absolute and relative times and their conceptions of changes (and underlying causes) that occur to life and the planet?

3. How do these conceptualizations explicate interdisciplinary integration of concepts within school curriculum?

Sample

- First-year students from the United States
  (N=224; 55,6 % ♀; 44,4 % ♂)
- First-Year students from Germany
 (N=69; 57,1 % ♀; 42,9 % ♂)

Survey

- Participants were asked to place five events on a time line: Earth's formation, appearance of life, appearance of dinosaurs, disappearance of four-legged dinosaurs, and appearance of man.
- Participants documented also absolute ages for Earth's formation and appearance of life.
- Participants were asked about changes in Earth Size and Continental position in past…(see below!)

The image to the right represents the Earth TODAY.

Think back in time to when you said the dinosaurs first appeared on Earth. What do you think the Earth and continents looked like then? Do you think the Earth was the same size as it is today, or has it shrunken or expanded? Choose the appropriate circle below and **draw what you think the Earth's continents looked like when dinosaurs first appeared on Earth.**
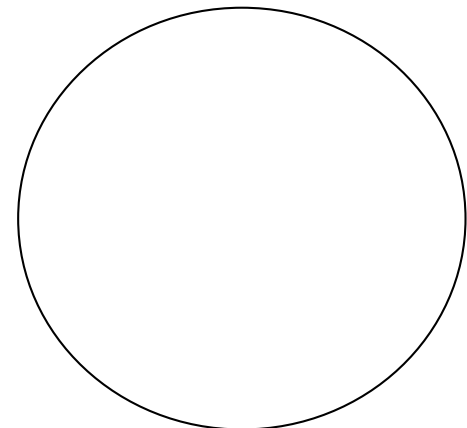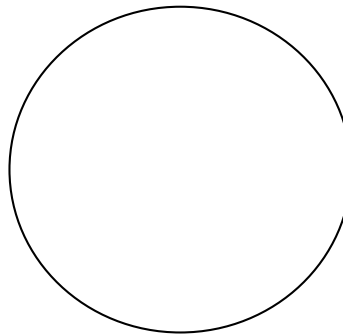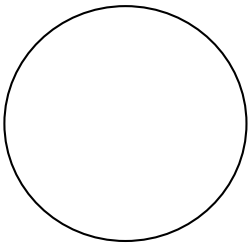
Survey

- … and in future!

Think into the future the same length of time you think passed between the first appearance of dinosaurs and today. What do you think the Earth and continents will look like then? Do you think the Earth will be the same size as it is today, or will it shrink or expand? Choose the appropriate circle below and **draw what you think the Earth's continents will look like in this future**
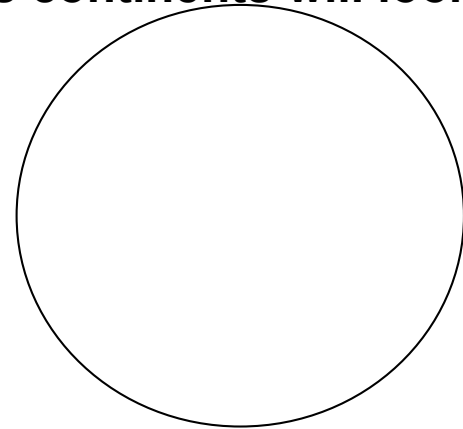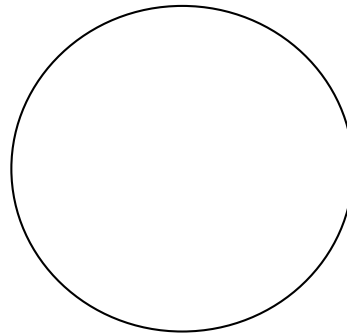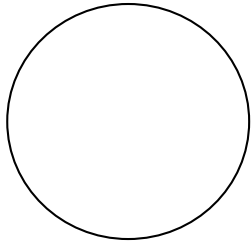
- Participants where asked why they think Earth`s size changes or remains the same over time
- Only U.S. Participants where asked why they think that Earth's surface changes or remains the same over time

Absolute Ages of Earth's Formation and Biological Events

	Scientific*	U.S. (n=224)	German (n=69)
Earth's Formation	4.6 billion	**Median:** 4.6 billion **Min:** 365 **Max:** 690 billion (n=121)	**Median:** 4.6 billion **Min:** 200 million **Max:** 500 billion (n=63)
Appearance of First Life	3.5 billion	**Median:** 500 million **Min:** 1 hundred **Max:** 50 billion (n=127)	**Median:** 1.5 billion **Min:** 1 million **Max:** 280 billion (n= 62)

Absolute Ages of Earth's Formation and Biological Events

	Scientific*	U.S. (n=224)	German (n=69)
Appearance of Dinosaurs	245 million	**Median:** 56 million **Min:** 1 hundred **Max:** 750 billion (n=132)	**Median:** 200 million **Min:** 500 thousand **Max:** 260 billion (n= 59)
Disappearance of Dinosaurs	66 million	**Median:** 500 million **Min:** 1 hundred **Max:** 50 billion (n=101)	**Median:** 65 million **Min:** 5 thousand **Max:** 250 billion (n= 48)

Absolute Ages of Earth's Formation and Biological Events

	Scientific*	U.S. (n=224)	German (n=69)
Appearance of Man	200000	**Median:** 500 million **Min:** 1 hundred **Max:** 50 billion (n=132)	**Median:** 150 thousand **Min:** 2,500 **Max:** 2 billion (n= 64)

Table 1. Response Rates and Maximum, Minimum, and Median Values for Absolute Age of Events in Years. *Absolute ages from Catley and Novick (2009). (Jaimes, Libarkin & Conrad, in press)

Absolute Ages of Earth's Formation and Biological Events

| Identified Subgroups	U.S.	German
Young Earthers (believe that earth is less than 100.000 years old)	7 % (n=9)	0 %
Young Lifers (believe that life on Earth is less than 100.000 years old)	20 % (n= 25)	0 %
Creationists (made biblical references e.g. god, the great flood and B.C.)	12 % (n= 27)	0 %

Table 2. Identified subgroups

Relative Ages of Earth's Formation and Biological Events

- Relative placement of events was done in a correct order by most of the participants in both groups, but the intervals between these events were often not correct.
- German students generally depicted biological events with more accuracy – both in terms of relative placement and order of events,

A typical German Drawing

Erstes Leben = first Life
Menschen= man
Entstehung der Erde= Earth Forms
Heute = Today
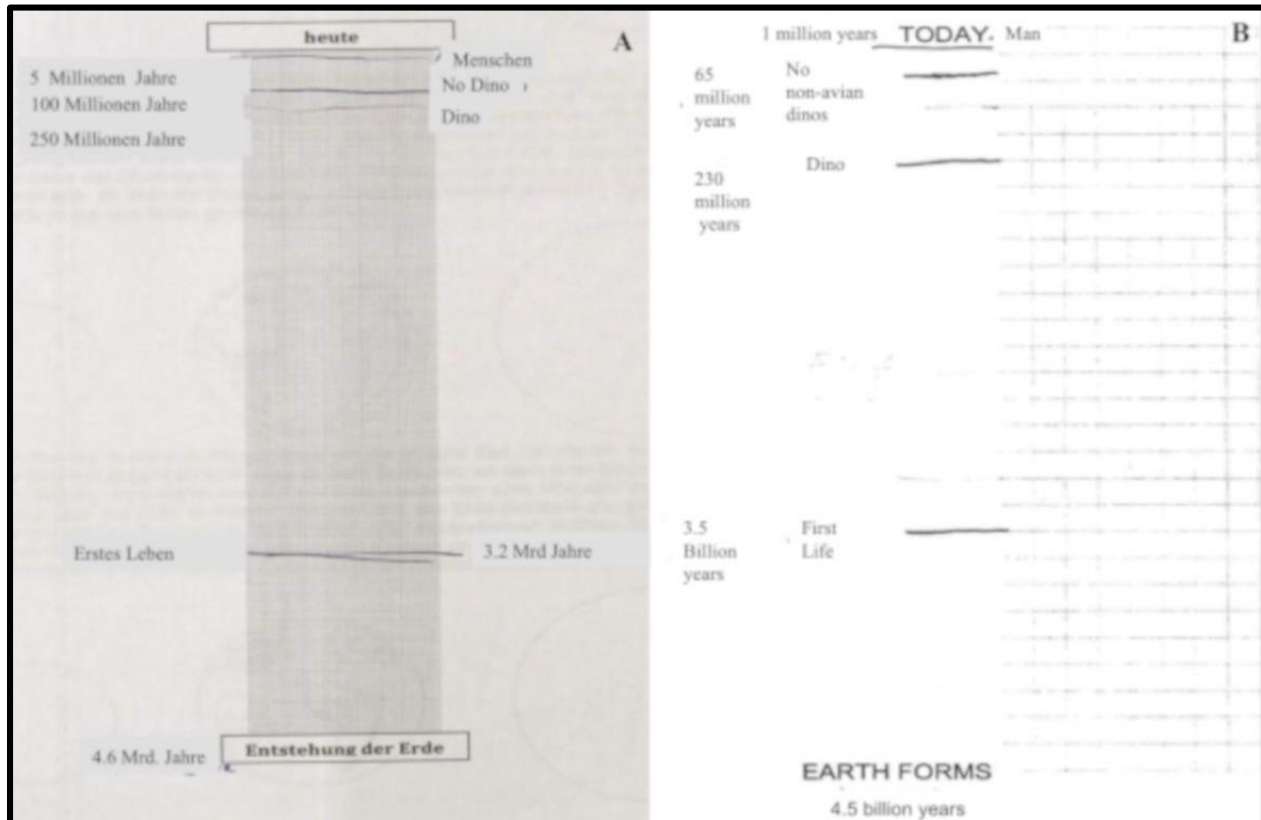
B An accurate Drawing of an U.S participant

(Jaimes, Libarkin & Conrad, in press)

Relative Ages of Earth's Formation and Biological Events

C typical U.S. Young life understanding

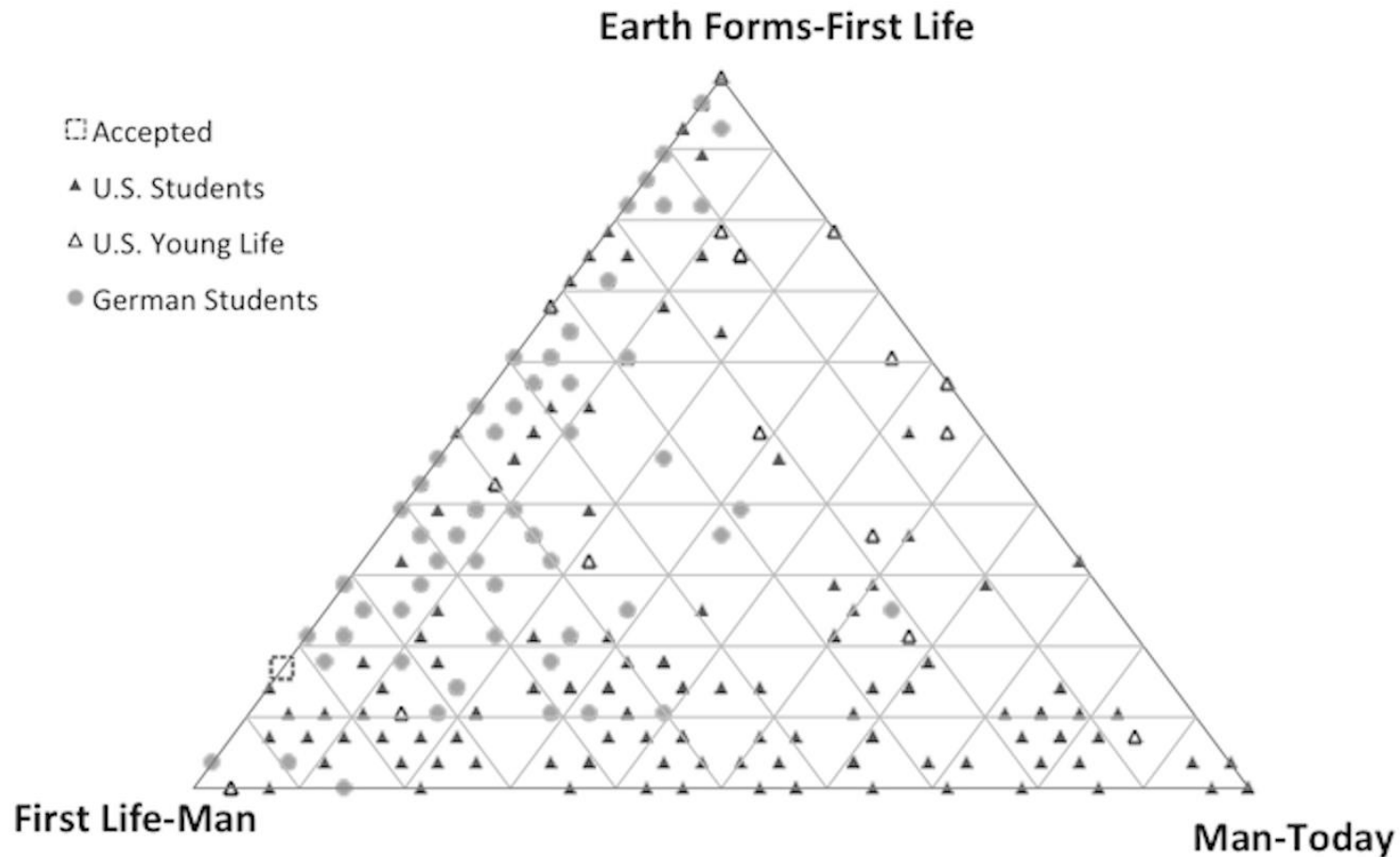**D** Example of inaccurate perception of relative and absolute ages of major evolutionary events (U.S. participant)
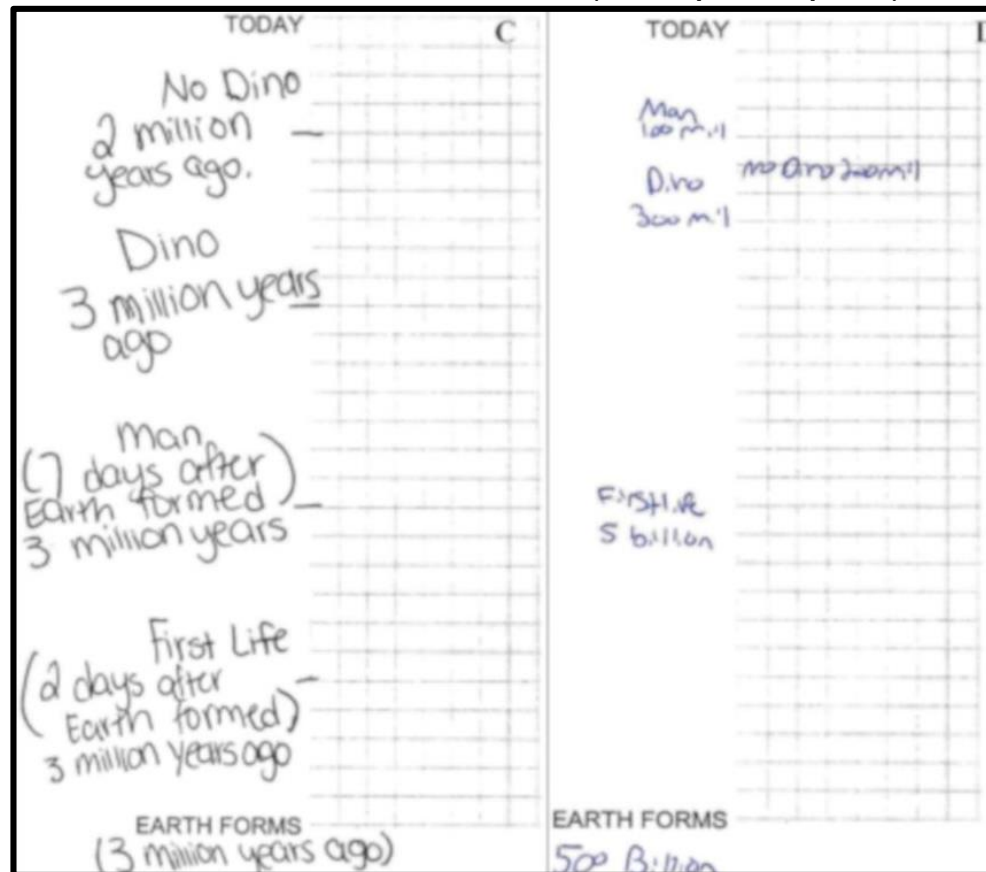
(Jaimes, Libarkin & Conrad, in press)

Relative Ages of Earth's Formation and Biological Events

(Jaimes, Libarkin & Conrad, in press)

Earth's Size

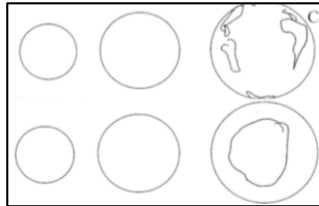| Conception	Example	Statistics
Earth`s size do not change		U.S. 72 % (n=144) German 90 % (n=62)
Mixed conception		U.S. 22% (n=43) German 5,8%(n=4)
Growing Earth		U.S. 4 % (n=8) German 2,9 % (n=2)
Shrinking Earth		U.S. 2.5% (n=5) German 1,4% (n=1)
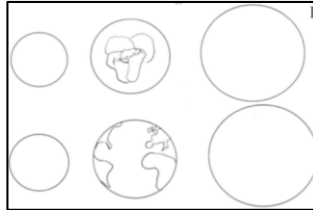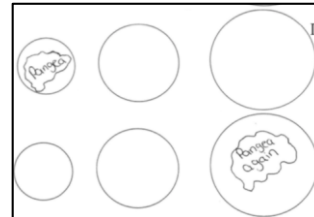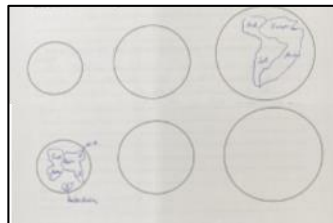
(Jaimes, Libarkin & Conrad, in press)

Changes to Earth`s surface

Point in time	Position of the continents	U.S. (N=214)	German (N=69)
Past	Super Continent	81 % (n=174)	79 % (n=55)
	Continents apart	8,4 %(n=18)	10 % (n=7)
	Same position as today	1,4 % (n=3)	1,4 % (n=1)
	Let out of responses	3,7 % (n=8)	10 % (n=7)
Future	Super Continent	14 % (n=30)	39 % (n=27)
	Continents apart	70 % (n=150)	46 % (n=32)
	Same position as today	4.7 % (n=10)	0 %
	Let out of responses	1,9 % (n=13)	14.3% (n=10)

Table 3. Conceptions about changes to Earth`s surface over time (Jaimes, Libarkin & Conrad, in press)

Explanation for Changes to Earth's Surface

- Only U.S. Participants has been asked, why they think that Earth's surface changes or remains the same over time
- 82 % argued that Change of continental position is caused by plate tectonics.

Students` explanations	Representative Student Quotes
Plate Tectonics	"Earths surface is constantly changing b/c of the plates moving and separating or joining countries together." (U.S., Creationist)
Erosion	"The Earth's surface changes because of wind erosion, global warming, and other environmental factors." (U.S.)
Natural Disasters	"Natural disasters such as Earthquakes or volcanic eruptions erode and change the Earth." (U.S.)

Table 3. Conceptions about causes of changes to Earth`s surface over time (Jaimes, Libarkin & Conrad, in press)

In what ways do students conceptualize large-scale changes to Earth's biology, continental positions, and size over long geologic time?

- Most participants in the two study samples placed evolutionary events in an accurate chronological order

- The majority of participants in both groups showed difficulties concerning the absolute ages of events and the time span between those events.

- Major difference between U.S. and German samples: All observed Creationist and/or Young Earthers/ Young Lifers belonged to the U.S. group. This is probably related to a more prominent role of religion in U.S. culture (Gallup, 2017)

In what ways do students conceptualize large-scale changes to Earth's biology, continental positions, and size over long geologic time?

- Alternative conceptions of changes to Earth`s size are similar to historical views (Shrinking Earth Theory; Expanding Earth Theory), but differ from historical views in terms of the assumed causes of shrinkage or growth.

- Typical difficulties in understanding geoscience become visible in students conceptions about causes of shrinkage or growth
  - Students often have difficulty handling of spatial scale levels (Trend, 1998, 2001; Libarkin, et al., 2007; Catley & Novick, 2009; Cheek, 2013)
    - Example: Earth will grow "because of material from space size…"
  - Students tend to structure processes as linear, but not as cyclic results (Felzmann, 2014)
    - Example: "Earth will grow over time because of volcanic eruptions"

.

What relationships, if any, exist between student paradigms about absolute and relative times and their conceptions (and underlying causes) that occur to life and the planet?

- As in other studies (Trend, 1998, 2001; et al., 2007; Catley & Novick, 2009) students of both groups held misconceptions about absolute and relative ages of evolutionary events
  - Most other research has been conducted only with U.S. students, our study used samples of two countries.
  - Most other studies focused on historical geological events – our study explored conceptions of evolutionary and geological events.
- All participants with Creationist or Young Life/Young Earth belonged to the U.S. Group.
- Reasons of not accepting Theory of Evolution could be (Deniz, Donelly, & Yilmaz, 2007; Lombrozo et al., 2008; Akyol, Tekkaya, Sungur, and Traynor, 2012; Dunk, Petto, Wiles, & Campbell, 2017; Ha et al., 2019; Fiedler, Sbeglia, Nehm, and Harms, 2019).
  - Religion
  - Understanding the nature of science
  - Thinking dispositions
  - Statistical reasoning

What relationships, if any, exist between student paradigms about absolute and relative times and their conceptions (and underlying causes) that occur to life and the planet?

- One often made recommendation for educators is to focus to focus on the nature of how the science works(Lammert, 2012; Sharmann, 2018) and utilize culturally competent teaching practices (Barnes & Brownell, 2017)

→ Students who understand the nature of science could better review anti evolution messages and could differ between a religious and a scientific context (Johnson & Peeples, 1987; Lombrozo et al., 2008; Akyol, Tekkaya, Sungur, and Traynor, 2012).

How does this research explicate interdisciplinary integration of concepts within school curriculum?

- Individuals with Creationist perspectives did not have difficulties with referencing the Theory of Plate Tectonics
    - → Why Theory of Plate Tectonics is easier to accept or understand for them?
    - → **Could Co-teaching Plate Tectonics and Evolution, using a culturally competent teaching approach promote acceptance and/or better understanding of the Theory of Evolution?**

Traditionally, the Theory of Evolution and the Theory of Plate Tectonics are taught as separate entities in bioscience and geology/geography courses.

BUT:

- Distribution of the Continents influences evolution of Life!
- **Could Co-teaching both Theories promote a better understanding of both Theories?**

How does this research explicate interdisciplinary integration of concepts within school curriculum?

- Co-teaching evolution and plate tectonics should
  - be based on conceptual change theory (Posner et al., 1982)
  - be combined with teaching the nature of how science works (Lombrozzo et al., 2008)
  - not aim to change students` belief but help students to differ between a scienitific and religion context and provide the foundational knowledge needed to understand (and possibly accept) difficult concepts within the context of scientific inquiry
  - provide instruction using culturally competent educational practices (Allen, 2007; Barnes &Brownell, 2017)

Read more:

Jaimes, P., Libarkin, J. & Conrad, D. (in press). College Student Conceptions About Changes To Earth And Life Over Time. *CBE-Life Science Education.*

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