Development of an Introductory Oceanography Concept Inventory Survey

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Background

Concept inventories are one type of assessment that can be used to evaluate whether a student has an accurate and working knowledge of a specific set of concepts. Such assessment tools have been developed in astronomy, biology, chemistry, engineering, fluid mechanics, geology, and physics; however, none has yet been available in oceanography. Our development of an Introductory Oceanography Concept Inventory Survey (IO-CIS) serves to fill this gap.

Approach and Design

Development of the IO-CIS took place in the context of the *Introduction to Oceanography* course taught at the University of Colorado at Boulder. The first step in the development of the IO-CIS entailed identifying and selecting the critical concepts to be addressed in the course and in the survey (Step 1). Next, concept-specific learning goals were defined for each critical concept (Step 2). These learning goals then provided the basis for framing open-ended questions that were administered to students in pre-module in-class Concept Inventory Exercises (CIEs) (Step 3, Round A). These open ended-questions each underwent validation and revision with expert and novice input prior to being administered in a CIE. Each CIE was comprised of four to five open-ended questions, and each contained one to four parts.

During the semester, four different CIEs were administered, with the number of respondents for each CIE ranging from 57 to 134. Student responses were then binned according to misconceptions and alternate conceptions, tallied, and distractors (i.e. multiple choice answers) were written based on the most popular bins using the same language and diagrams employed by students in their responses (Step 4 and 5).

Student responses were also used as part of the validation process of the IO-CIS to ensure that the questions were interpreted by students in the manner intended. Student responses were also used as a basis to discard particular questions from inclusion in the overall IO-CIS. After the initial IO-CIS questions and distractors had been designed as described above, 23 one-on-one student interviews were conducted as part of the validation process (Step 3, Round B; Step 6).

As a result of the development approach employed, a wide variety of student misconceptions and alternate conceptions regarding critical concepts in this *Introductory Oceanography* course were revealed and implemented in the design of the IO-CIS (Step 4). The IO-CIS can now be administered as a pre- and post-instruction survey as a means of assessing students' learning gains in the course for which it was designed. Additionally, there exists potential to further develop the IO-CIS as an assessment tool that may be implemented

Results

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Step 1: Identify critical concepts for the course. Of the identified course concepts, eleven are covered in the IO-CIS.

- Density stratification (5) - Isostatic equilibrium (3)
- Convection (4) - Heat and temperature (2)
- Biogeochemical cycling (1) - Coriolis effect (2)
- Geostrophic flow (2) - Thermohaline flow (1)
- Food chain efficiency (1) - Chemosynthesis (2)
- Deep versus shallow water waves (1)

The number in ( ) indicates the number of questions in the IO-CIS that address the concept.

Step 2: Define learning goals for each critical concept.

Density stratification
Explain the layering of the Earth's interior as a function of composition, temperature, and pressure.

Isostatic equilibrium
Predict how surface topography would vary with crustal density and thickness.

Convection
Describe the conditions necessary for the development of a convection cell.

Heat and temperature
Appraise the importance of water's high latent heats of fusion and vaporization in moderating Earth's temperature.

The above represents a sampling of learning goals for several critical concepts covered in the IO-CIS.

Step 3: Frame open-ended questions, which address the concept-based learning goals, for the CIEs (Round A) and the IO-CIS (Round B)

Round A: CIE question based on expert and novice input (drafting)
Ocean basins (below sea level) are topographically lower than continents (mostly visible above sea level. Why are *ocean basins* topographically lower than continents?

Round B: IO-CIS question based on further novice input (interviews)
Ocean basins (large regions of Earth's crust situated below seal level) are topographically lower than continents (mostly visible above sea level). Why are *ocean basins* topographically lower than continents?

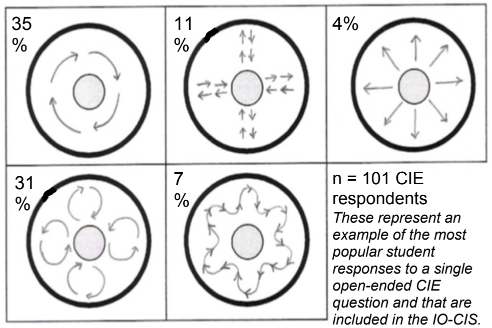
The above is an example of. an open-ended question that was drafted for a CIE and then modified for the IO-CIS based on student interviews.

Step 4: Collect students' responses to open-ended CIE questions, and identify student misconceptions.

- Continents float on water.
- Oceans basins are deep because the weight of seawater depresses oceanic crust.
- Mountains form because there is more soil and sediment beneath the crust in that area.
- The largest mountains form due to earthquakes.
- The mantle is all magma.
- Magnetic forces drive mantle convection.
- Rocks contain cells that can move closer or farther apart from one another.
  - The gravitational pull on Earth's different hemispheres cause hurricanes to rotate in opposite directions.

The above is a sampling of student misconceptions revealed through the CIEs.

Step 5: Bin student responses to open-ended CIE questions, and use most popular responses (written and/or drawn) as the multiple choice answers for the same question in the IO-CIS.



n = 101 CIE respondents

These represent an example of the most popular student responses to a single open-ended CIE question and that are included in the IO-CIS.

Step 6: Validate IO-CIS through student interviews.

Twenty-three one-on-one student interviews were conducted to ensure that students interpreted the questions and answer choices as intended (overlap with Step 3, Round B).

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