Distinguishing Evolution Ideas through Two Different Forms of Collaborative Critique-Focused Concept Mapping Activities

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Abstract: Understanding evolution requires distinguishing ideas on observable (organism) and unobservable (genetic) levels. This study explored two different treatment groups using a novel form of concept map that elicits connections between levels: Student dyads compared their concept maps against an expert-generated or a peer-generated concept map. Both groups made significant gains connecting evolution ideas across levels, but used different criteria: The expert-map group focused mostly on surface criteria while the peer-review group used more specific criteria.

Objectives

Evolution ideas are found on multiple connected levels, for example genetic, cell, and organism. This study aims to connect evolution ideas through dynamic computer-based inquiry activities and collaborative concept maps activities. Generating a coherent concept map often requires a subsequent revision step (Schwendimann, 2007). Revision activities require students to generate criteria that allow comparing against a benchmark. This study compares two different collaborative biology-specific concept map critique activities: Expert-generated benchmark maps vs. peer-generated benchmark maps.

Theoretical Framework

This study uses the knowledge integration framework (Linn, Davis, & Eylon, 2004) as its operational framework to build and evaluate a curriculum that focuses on the connections between ideas on a genetic, cellular, and organism level. This study proposes a novel form of non-hierarchical biology-specific concept map that is divided into three field-specific areas (genetic, cellular, and organism/population).

Research Questions

This study investigated two research questions: 1) How does collaborative comparison and critique of biology-specific concept maps against expert or peer benchmark maps impact learning about evolution? 2) What criteria do students collaboratively generate for comparing individual concept maps against expert and peer work?

Methods

The weeklong WISE module *Space Colony – Genetic diversity and survival* was implemented by two teachers, each with two 9th and 10th grade classes in the same public high school (n=81). One class from each teacher was randomly selected for either treatment (expert map or peer map comparison). During the project, students worked collaboratively in randomly assigned dyads. *Space Colony* included the dynamic population genetics visualization *EvolutionLab* (biologyinmotion.com, n.d.) that allowed students to investigate the effects of mutation rate and natural selection on genetic diversity. Following the *EvolutionLab* activity, students worked in dyads creating concept maps from six given ideas. First, students placed each idea in the corresponding area (genetic, cellular, or organism/population), and connected ideas with labeled arrows. Following the concept map construction, the students compared their concept map against a benchmark map – either an expert-constructed map or the map of an anonymous peer. Each dyad decided upon and negotiated its own criteria.

Data Sources

Pretest and posttests consisted of nine multiple choice and explanation items that assessed changes in students' connections between genetic and evolution concepts. Tests were coded using a five-scale knowledge integration rubric (Linn, Lee, Tinker, Husic, & Chiu, 2006). Concept maps propositions were coded on a five-scale knowledge integration rubric for concept maps (Schwendimann, 2008). The rubric distinguishes between link label, link direction, concept placement, and cross-links.

Results

Research question 1: Results suggest that the combination of critique-focused concept mapping and a dynamic visualization helped students in both treatment groups generating novel connections between ideas in different levels. Both treatment groups showed equal gains from pretest to posttest, $t(80) = 4.151$, $p<0.001$, Effect size (Cohen's d)=0.52 (SD pretest=2.78, SD posttest=3.17)]. However, regression analysis indicates that the peer map group created more cross-links after the revision than the expert map group (while keeping the coefficient for the initial number of cross-links constant), $R2=0.9917$, $F(2,78)= 4680.91$, $p=0.025$

Research question 2: Results suggest that both treatment groups significantly improved their concept maps through the critique activity, $t(80) = 4.13$, $p<0.001$. Students in both treatment groups used a broad variety of criteria to review and compare different aspects of concept maps. However, the two treatment groups differed in their use of different criteria: Students in the expert-map group used mostly concept placement criteria (31%). Seven percent critiqued a missing link label and 6% suggested changing an existing link label. Students in the peer-map group used a larger variety of criteria. Sixteen percent also criticized the misplacement of a concept and 11% pointed out a missing label, but another 9% suggested adding a missing link, and 2% analyzed the direction of an arrow.

Discussion

Findings suggest that the WISE module *'Space colony'* helped students in both treatment groups to integrate their evolution ideas within and across levels. The visual structure of biology-specific concepts maps can support collaborative critique activities. Many students in the expert-comparison group seem to have interpreted the expert map as the one "correct" solution. Results indicate that students in the peer critique group used a wider variety of criteria, especially criteria that require conceptual reflection (label revision, arrow direction, and adding a link). Critiquing peer work sets students in a position of equal authority to critique each other's work while valuing their own ideas. Peer work is often using familiar vocabulary and can be more accessible to students than expert work.

Significance and Implications

Both critique activities can support reflection through criteria generation and revision. Critical reflection can support students' self-monitoring of their learning progress. When designing collaborative critique activities, expert and/or peer work critique could be used to support different forms of critique toward a more coherent understanding of biology ideas.

References

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