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Analyzing the Structure of Student Sustainability Knowledge using Traditional and Holistic Concept Map Scoring Methods

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ABSTRACT

To properly initiate educational reforms needed to train sustainability-conscious engineers, methods are needed to assess conceptual understanding of sustainability. Concept maps (cmaps) have been proposed as useful tools for capturing the complexity and interconnectedness of sustainability; however, difficulties in scoring cmaps have limited their application as assessment tools. The goal of this project was to examine the effectiveness of traditional and holistic cmap scoring approaches for characterizing student understanding of sustainability.

Cmaps were used to assess structure of student sustainability knowledge in a capstone design course and a graduate seminar in Civil and Environmental Engineering (CEE) at Georgia Tech. Judges applying traditional and holistic cmap scoring methods demonstrated at least substantial agreement (κCohen > 0.60). Convergent validity was also shown for the two scoring approaches. Use of traditional and holistic procedures suggested that graduate students possess more sophisticated semantic networks related to sustainability compared to undergraduates. Data on CEE student sustainability knowledge can be used to guide efforts to integrate sustainability into undergraduate curricula. More broadly, study results demonstrate that cmaps can be used as valid and reliable assessment tools.

INTRODUCTION

Sustainable Engineering: Although technology has contributed to current unsustainable practices, engineering is important for promoting future sustainable development. Sustainable engineering is a new field aimed at balancing economic, environmental, and social systems during development. To properly initiate educational reforms needed to train sustainability-conscious engineers, methods are needed to assess conceptual understanding of sustainability (Figure 1).

EXPERIMENTAL METHODS

Student Populations: CEE students enrolled in a capstone design (n = 51) course and a graduate transportation seminar (n = 12) participated in a cmap workshop where they created cmaps on the focus question: “What is sustainability?”

Traditional Cmap Scoring: Two expert judges quantified the number of concepts (NC), highest hierarchy (HH), and number of cross-links (NCL) to characterize breadth, depth, and connectedness of knowledge, as per Novak[8].

Holistic Cmap Scoring: Two expert judges characterized comprehensiveness, organization, and correctness of cmaps using a validated rubric developed by Besterfield-Sacre[2].

RESULTS AND DISCUSSION

Objective 1: Cmaps can be reliably scored (κCohen > 0.60) using traditional or holistic approaches by trained judges.

Objective 2: Both scoring procedures show convergent validity for quantifying knowledge depth, breadth, and connectedness in cmaps.

Objective 3: Traditional and holistic scoring methods can discern differences in knowledge breadth, depth, and connectedness of sustainability knowledge.

Objective 4: Since undergraduates had statistically fewer cross-links than graduates, improvements to CEE curricula may be needed to teach students about the interrelated nature of sustainability.

CONCLUSIONS

Holistic Method Outcomes: Holistic scores also revealed graduates’ sustainability knowledge networks to be more complex than those of undergraduates. Specifically, graduates’ total holistic scores were significantly higher (p = 0.027) than undergraduates (Figure 6). Thus, the holistic method was also able to capture differences in student sustainability knowledge.

REFERENCES