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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 (kappa > 0.60). Convergent validity was also shown for the two scoring approaches. Results of traditional and holistic procedures suggested that graduate students possess more sophisticated semantic networks related to sustainability than undergraduates. Data on CEE student sustainability knowledge can be used to guide efforts to improve sustainability education in 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).

Objective:
1. To determine the reliability and validity of traditional and holistic cmap scoring methods.
2. To analyze the ability of scoring approaches to discern differences in sustainability knowledge between undergraduates and graduates.
3. To provide insights into improving sustainability education in Civil and Environmental Engineering (CEE) at Georgia Tech using cmap data.

OBJECTIVES

1. To determine the reliability and validity of traditional and holistic cmap scoring methods.
2. To analyze the ability of scoring approaches to discern differences in sustainability knowledge between undergraduates and graduates.
3. To provide insights into improving sustainability education in Civil and Environmental Engineering (CEE) at Georgia Tech using cmap data.

Theoretical Basis

Use of cmaps is supported by semantic memory theory, which posits that knowledge networks are formed by creating directed links between concepts. Since cmaps mimic internal semantic networks, they may be used to infer structure of student understanding.

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

Results and Discussion (Cont.)

Reliability: Both the traditional holistic scoring methods were highly reliable. Cohen’s kappa, a very conservative measure of interrater reliability, was within the substantial agreement range (kappa = 0.678**) for all sub-scores (Figure 4). Thus, properly-trained judges can be used to reliably score cmaps using either traditional or holistic scoring procedures.

Validity: Spearman correlations between traditional and holistic subscores that quantify similar cmap characteristics (i.e. NC and organization) and lack of correlations between subscores that quantify different cmap qualities (Table 1) suggest convergent validity for the two scoring approaches. Thus, both methods can be used to characterize breadth, depth, and connectedness of sustainability knowledge.

Table 1. Spearman correlations between traditional and holistic subscores.

<table>
<thead>
<tr>
<th>Traditional Subscore</th>
<th>Traditional Subscore</th>
<th>Holistic Subscore</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>HH</td>
<td>NCL</td>
</tr>
<tr>
<td>Correctness</td>
<td>0.475*</td>
<td>0.274*</td>
</tr>
<tr>
<td>Organization</td>
<td>-0.107</td>
<td>0.066</td>
</tr>
<tr>
<td>Correctness</td>
<td>0.160</td>
<td>-0.079</td>
</tr>
</tbody>
</table>

REFERENCES