Innovative Tools for Assessing Student Sustainability Knowledge

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Abstract

A workshop will be conducted to introduce tools for assessing students' conceptual and applied sustainability knowledge. First, concept maps will be presented as direct measures of students' conceptual understanding of sustainability. Participants will construct their own sustainability concept maps, as well as practice applying scoring methods. Given that scoring is the major barrier to application of concept maps, an automated scoring program will be provided to participants. Finally, methods for assessing students' abilities to engage in sustainable design will be presented. Focus will be on a newly-revised, cross-disciplinary sustainable design rubric. Participants will have an opportunity to provide feedback on the validity of the rubric, and they will be provided with documentation on how to apply the rubric in their own classes. Overall, participants will be provided with a framework for classifying different types of sustainability assessments and practical methods for assessing students' conceptual and applied understanding of sustainability in engineering contexts.

Keywords

Sustainability, Concept Maps, Design Rubric, Assessment

Introduction

Engineers, regardless of discipline, will be poised to make critical decisions that impact the sustainability of infrastructure, products, and processes. Consequently, the literature is ripe with reports of efforts to update undergraduate curricula to train engineers to operate under a sustainable design paradigm. Integral to the design and monitoring of reform efforts will be the availability of accurate and reliable tools for assessing students' conceptual and applied knowledge of sustainability[1].

Assessment of Conceptual Understanding of Sustainability

Several tools are available for assessing students' conceptual understanding of sustainability. Most commonly in the literature, student sustainability knowledge is captured indirectly using surveys to ask students to rate their own understanding[2]. For example, Kagawa[3] asked participants to rate their sustainability knowledge as either "very familiar", "quite familiar", or "quite unfamiliar/not at all familiar." Watson et al.[4] used several seven-point Likert scale survey items to compare students' ratings of the importance of and their confidence in sustainability and related dimensions. Other examples of using surveys to assess student sustainability knowledge abound in the literature.

While surveys can provide valuable insights into students' attitudes toward sustainability and engineering values, direct assessments often provide a more accurate and complete picture of

student understanding[5]. For example, the Structure of Observed Learning Outcomes (SOLO) taxonomy can be used to track development of student sustainability knowledge by reviewing work products like short answer questions or essays[6-8]. According to the SOLO taxonomy, students progress through five stages in their development of understanding in any domain[9]. Beginning in the *pre-structural* phase, students have virtually no knowledge of the subject. The *uni-structural* and *multi-structural* stages consist of students acquiring fundamental content knowledge. Afterward, students move beyond content knowledge and begin to develop structural complexity as they see relationships between concepts in the *relational* phase. Finally, students acquire the ability to generalize concepts beyond the context in which they were learned in the *extended abstract* phase[7,9]. Indeed, authors such as Carew and Mitchell[7], Hayles de la Harpe[10], Nicolaou and Conlon[6], and Watson et al.[11] have classified student-provided definitions of sustainability according to the five SOLO taxonomy categories.

Concept maps, which are graphical tools for organizing knowledge, can also be used as direct assessments of student sustainability knowledge[5, 12-14]. Students construct concept maps by arranging related concepts and using directive, descriptive linking lines to show relationships between those concepts[15]. Constructing concept maps allows students to freely reveal both the content and structure of their understanding, which makes them appropriate for analyzing how well students grasp the inherent interrelationships between sustainability dimensions[16]. Although concept maps are promising as sustainability knowledge assessments, difficulty in scoring the constructs are a barrier to their application in engineering education[5,14].

Assessment of Sustainable Design Abilities

While it is critical to ensure that students grasp the complexity of sustainability topics, it is especially important for engineering students to be able to apply this knowledge in the design process. Unfortunately, less discussion in the literature has been devoted to how to assess student sustainable design abilities. Indirectly, students can be surveyed on their confidence in their sustainable design abilities[1]. More directly, Watson et al. developed a sustainable design rubric, based on the Nine Principles of Sustainable Engineering, to judge the extent to which sustainability is incorporated into student-level projects[17]. Currently, work is underway to update the Watson et al. rubric to be used in cross-disciplinary engineering contexts[18].

Learning Objectives/Outcomes

An interactive workshop will be conducted to disseminate a variety of tools for assessing student sustainability knowledge. After participation in the workshop, participants will be able to:

1. Identify and describe direct and indirect measures of students' conceptual understanding of sustainability.
2. Design and score concept-map-based assessments for directly measuring students' understanding of sustainability.
3. Identify and describe direct and indirect measures of students' abilities to apply sustainability concepts and principles during design.
4. Apply a cross-disciplinary, project-level rubric to capture students' abilities to engage in sustainable design.

5. Compare strengths and weaknesses of different assessment methods to capture values/attitudes, conceptual knowledge, and applications of knowledge in order to choose an appropriate method for a course or curricular context.

Through participation in the workshop, participants will be provided with a variety of tangible resources for applying sustainability assessment tools in their own courses and programs:

1. A listing of existing surveys for indirectly assessing student sustainability knowledge
2. Handouts for concept-map-based assessments and access to a scoring program
3. A sustainable design rubric for assessing student-level projects
4. Summary of key literature related to assessment of sustainability education

Workshop Agenda/Timeline

Short presentations and activities will be used to present innovative tools for capturing students' conceptual and applied sustainability knowledge (Table 1). All handouts and required materials will be provided to participants on site. Participants are encouraged to bring their laptops to explore several electronic programs that will be presented.

Table 1. Outline of workshop activities.

Part 1: Introduction and Workshop Overview	**10 minutes**
Topic – Framework for classifying sustainability assessments	5 minutes
Reflection – How do you assess sustainability knowledge and skills?	5 minutes
Part 2: Tools for Assessing Conceptual Knowledge of Sustainability	**60 minutes**
Topic – Summary of indirect and direct assessment methods	10 minutes
Topic – Concept maps as a direct assessment tool	10 minutes
Activity – Constructing sustainability concept maps	10 minutes
Topic – Scoring concept maps	10 minutes
Activity – Using the traditional method to score concept maps	10 minutes
Demonstration – Automated scoring of concept maps	5 minutes
Reflection – Opportunities to integrate tools into classes and programs	5 minutes
Part 3: Tools for Assessing Sustainable Design Skills	**40 minutes**
Topic – Summary of indirect and direct assessment methods	10 minutes
Topic – A cross-disciplinary, project-level sustainable design rubric	10 minutes
Activity – Application of sustainable design rubric	15 minutes
Reflection – Opportunities to integrate tools into classes and programs	5 minutes
Part 4: Summary and Closing	**10 minutes**
Topic – Discussion of additional assessment resources	5 minutes
Reflection – Completion of workshop evaluation	5 minutes

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Elise Barrella

Dr. Elise Barrella is Assistant Professor of Engineering at James Madison University and was recently recognized with the university's Junior Scholar Award. Prior to joining the Madison Engineering faculty, Dr. Barrella completed her Ph.D. at Georgia Institute of Technology as part of the Infrastructure Research Group. Her scholarly interests focus on two areas: community-based design and urban planning, including the use of sustainability rating systems, and engineering education for sustainability. In addition to teaching and student mentoring, Dr. Barrella is engaged in research projects sponsored by National Science Foundation investigating engineering students' application of sustainability concepts across courses and project contexts.