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Educating in an Era of Continuous Change

Virtual hotels, real skills: Developing sustainability competencies through simulation

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This paper describes the development and implementation of an innovative hotel carbon reduction simulation aimed at developing sustainability competencies in business students. Using the Harvard Business School "Net Zero" simulation, we assess how interactive simulation-based learning opportunities improve students' self-assessment of the eight sustainability competencies with a mixed-methods approach. The research examines critical gaps in knowledge of how simulation-based methods can develop integrated competency sets needed to solve complex sustainability challenges. The simulation assigns around 950 first-year management students as hotel managers tasked with achieving 50% emission reductions over seven years while maintaining financial performance. Students select from 29 sustainability initiatives across Energy, Purchasing, and Management categories, working within realistic constraints of carbon budgets, site-specific emission factors, and dynamic market conditions. Our comprehensive analytical design combines pre-post competency surveys with cluster analysis of strategic approaches, and qualitative analysis of learning reflections. Anticipated outcomes are enhanced competency development across all eight dimensions, with gains in systems-thinking, futures-thinking, and implementation competencies. The research aims to provide empirical proof for developing specific sustainability competences as well as demonstrating scalable approaches of integrating sustainability education into core business curriculum.

Keywords: sustainability education, simulation-based learning, sustainability competency development, business education, experiential learning

Background

Never has there been greater urgency to equip business graduates with sustainability literacy. As organisations around the world set net-zero emission and sustainable operating targets, education institutions have a responsibility to prepare students to solve complex sustainability challenges. Yet, conventional approaches to sustainability education routinely neglect to cultivate the integrated skills for actual practice, treating sustainability as a second-tier subject instead of promoting the systems thinking and implementation skills necessary for effective transformation.

This innovative project aims to assist in building sustainability competencies in business students. Using an established simulation, we develop and implement a self-assessed measure of sustainability competencies along with a reflective task and teaching plan. These materials can subsequently be adopted across contexts and disciplines to assist in raising awareness and understanding of sustainability competencies and identifying areas of perceived weaknesses, thus assisting with sustainability competency development.

Sustainability competency frameworks

Recent studies have highlighted the necessity of building general sustainability competencies in business education. Despite initial research results, there is a lack of consensus on how to define sustainability competencies (Wolbring & Burke, 2013). Sustainability competency models have evolved considerably. Brundiers et al. (2021) present a revised framework of key competencies in sustainability based on a Delphi study with 14 global experts in sustainability education, an expansion of a previous version by Wiek et al. (2011). The revised framework gives more precise definitions, suggests a hierarchical model, and adds two

new competencies. Expanding on this, Redman and Wiek (2021) designed a framework that included eight key competencies (Figure 1), providing a strong basis for sustainability education. Nevertheless, additional research is needed to examine how these competencies can be developed and practiced in actual learning settings (Redman & Wiek, 2021).
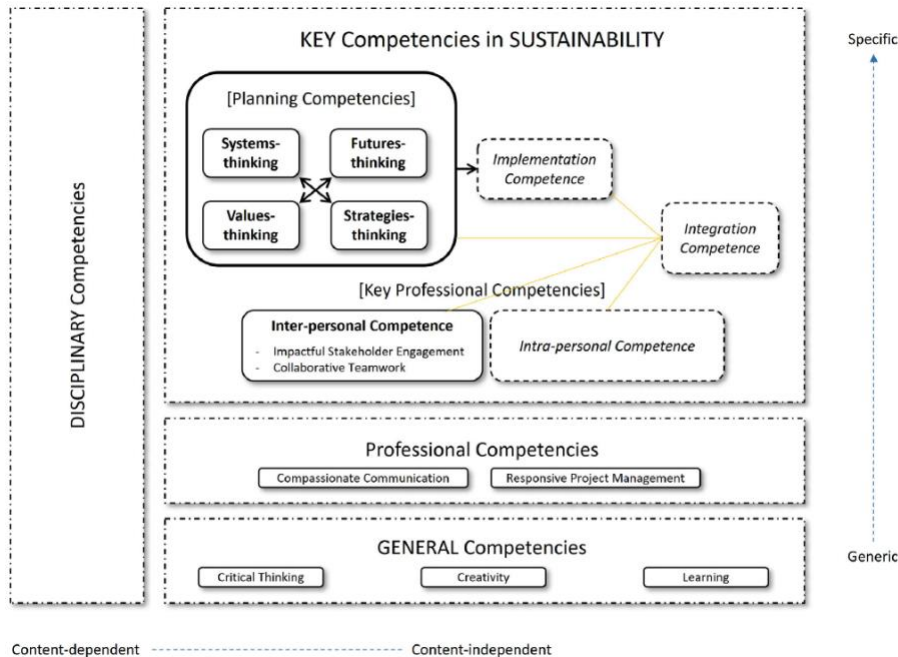

Figure 1. Unified framework of competencies (Redman & Wiek, 2021)

Systems-thinking competence is applying complex analytical techniques to understand sustainability problems in different fields and at different scales, including feedback loops and cascading effects (Connell et al., 2012).
Futures competence entails the ability to construct scenarios and visions for the purpose of projecting complex systems' states into the future (Gardiner & Riekmann, 2015).
Values-thinking is the ability to define and apply sustainability principles and values to assess current and future system states (Remington-Doucette et al., 2014).
Strategic thinking competency is concerned with action plan development and assessment, as well as sustainability planning (Wesselink et al., 2015).
Implementation competency pertains to the execution of sustainability initiatives by skilled and effective implementation, adaptation, and development (Perez Salgado et al., 2018).
Interpersonal competence involves working in interdisciplinary teams and close interaction with stakeholders (Brundiers & Wiek, 2017). This study emphasises essential roles of communication, empathy, and cultural competence in leadership for sustainability.
Intra-personal competence involves maintaining personal resilience and avoiding burnout by being self-aware and self-regulated (Giangrande et al., 2019).
Integration competence is the ability to bring together more than one competency simultaneously in tackling complex sustainability problems (Jegstad & Sinnes, 2015).

Simulation-based learning for sustainability education

Simulation-based learning represents a promising approach for developing sustainability competencies (Gatti et al., 2019). Simulation facilitates experiential learning by reproducing contexts that closely resemble reality (Tejedor et al., 2019). Simulation-based learning significantly improves education for sustainable development outcomes, where simulation is a powerful and efficient method to help students in understanding sustainability problems (Green et al., 2022). Recent research identifies a steady increase in the development of serious games focused on sustainable development as it represents an engaging and motivating way for students to learn about complex sustainability issues (Katsaliaki & Mustafee, 2015; Stanitsas et al., 2019,

Madani et al. 2017). Despite increasing research relating simulation to sustainability issues more broadly, there remains limited research into the role of simulation in developing sustainability competencies.

Yet we know relatively little from research regarding simulation's role in the development of the integrated competencies specified in contemporary frameworks. Most of the research has dealt with the development of individual competencies, not integrated competency development, a substantial gap filled by this research.

The Net Zero Simulation

The "Sustainability Management Simulation: Net Zero" is an advanced team (and single player) simulation where students manage a four-star hotel in New York, London, or Singapore with the goal of achieving 50% emissions reductions over seven years while maintaining good financial performance. Students select up to three initiatives each year from among 29 potential ones in energy (solar panels, LED lighting, electric vehicles), purchasing (water-efficient appliances, organic food, sustainable furniture), and management (employee training, guest communication, sustainability reporting).

The simulation incorporates real-world constraints like location-based emission factors, electricity price, and carbon intensity variation. Students work within a total carbon budget with annual emission reduction rates, grid decarbonisation rates, electricity price increases replicating the real world. An extensive dashboard that tracks consumption patterns, emissions by scope and source, and financial performance provides immediate feedback.

Research design

This research employs a mixed methods approach to evaluate the simulation's effectiveness in enhancing perceptions of sustainability competencies. Sustainability competencies are often assessed through students' self-rated agreement with competency statements (Redman et al., 2021). For this study, quantitative analysis will be performed on pre/post self-perception competency assessments, team performance metrics, and qualitative analysis of student learning through structured reflections. This approach ensures comprehensive evaluation of competency development across all eight dimensions. The research design includes:

Quantitative measurement through pre/post self-assessment competency testing of all eight of Redman and Wiek's (2021) competency dimensions. The comprehensive testing addresses each competency dimension through simulation exercises: systems-thinking, analysing interdependent hotel operations; futures-thinking, long-term implications; values-thinking, resolving ethical trade-offs; strategies-thinking, developing implementation plans; implementation competence, implementing sustainability practices; inter-personal competence, team building and stakeholder engagement; intra-personal competence, stress management and motivation; and integration competence, combining multiple perspectives and competencies.

Qualitative analysis involves conducting a thematic analysis of the structured reflections where students are asked to identify 3 sustainability competencies from Redman & Wiek's (2021) framework that were most significantly developed during the simulation. For each selected competency, students respond to three specific prompts: 1. describe specific situations or decisions from the simulation that engaged this competency, 2. analyse how the simulation helped develop their capabilities in this area, and 3. discuss how their learnings might apply to real-world sustainability challenges. To ensure reliability in the qualitative analysis, two researchers will independently code a subset of the reflections (20% of the sample) using an initial coding framework derived from the eight competency dimensions. Any discrepancies in coding will be discussed and resolved through consensus.

Instrument design
The sustainability competencies questionnaire was derived from several existing instruments. The questions on systems-thinking, futures-thinking, values-thinking, strategies-thinking, interpersonal competence was derived from Savage et al. (2015). Questions on implementation competence and integration competence was derived from Ploum et al. (2017). As there were no existing questions on intrapersonal competence, we developed questions based on Ayers et al. (2023). The instrument includes a total of 24 questions (3 for each competency). The questions on sustainability competencies will be the same for the pre- and post-simulation

surveys. However, additional post-simulation questions on behavioural change and application (5 questions), simulation design and learning experience (10 questions), as well as team (4 questions) and demographic information (6 questions) will be added. The surveys were created in Qualtrics.

Participants and implementation

Research participants include around 950 first year business students enrolled in MGC1010 (Introduction to Management). Students complete the pre-test survey before they start the simulation during their week 8 workshop. Students are then invited to complete the post-test survey at the end of Week 8, alongside their structured reflections.

Data analysis approach

The research employs multiple analytical strategies to maximise insights from the rich dataset. Paired t-tests will examine competency development for each dimension, while cluster analysis will group students based on initiative selection patterns, which may reveal strategic archetypes that can be correlated with competency development scores. Regression analysis will examine the relationships between simulation performance outcomes (emission reduction percentage, carbon budget utilisation, financial performance) and competency development. Qualitative data from the structured reflections will be analysed using thematic analysis to identify key insights and competency development narratives.

Expected outcomes and implications

Based on the theoretical foundation and simulation design, we anticipate several key outcomes. Students will demonstrate increased self-perceived competency across all eight dimensions, with gains in systems-thinking (through analysing hotel operations as interconnected systems), futures-thinking (through scenario planning for net-zero transitions), and implementation competence (through hands-on decision-making experiences). The simulation design will deliver varied levels of enhancement across competencies with implementation and integration competencies achieving significant gains since the experiential context. Analysis will illustrate how competencies reinforce each other within the simulation space, providing insight into the integrated nature of sustainability competency development.

Study limitations

While this research can provide valuable insights into simulation-based sustainability competency development, several limitations should be raised. The reliance on self-assessment measures may introduce response bias, and the focus on a single simulation platform within business management may limit generalisability to other disciplines. The short-term intervention (single week) may not capture long-term competency retention, and the first-year student population may have limited prior sustainability exposure, affecting baseline competency levels. Finally, the qualitative analysis relies on self-reported reflections, which may not fully capture unconscious competency development that could be complemented by observational methods.

Pedagogical implications

The research also contributes to understanding effective sustainability education approaches in several ways. We anticipate finding empirical evidence on the effectiveness of simulations in building capacities for sustainability, aside from showing how sustainability education may be integrated within core business curricula. The framework developed in this study offers significant potential for adaptation across diverse educational contexts (e.g. public policy programs could use urban planning or climate policy simulations; healthcare programs could employ hospital sustainability management scenario). The framework remains the same, but the applied context shifts to match disciplinary relevance.

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