Systems Thinking and Simulation for Sustainability Education

Subjects: Others | Environmental Studies

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Education for sustainable development (ESD) is considered vital to the success of the United Nations' sustainable development goals. Systems thinking has been identified as a core competency that must be included in ESD. However, systems thinking-orientated ESD learning tools, established methods for assessment of sustainability skills, and formal trials to demonstrate the effectiveness of such learning tools are all lacking. Furthermore, simulation is seen by many Systems Thinkers as essential for learning about complex systems. Therefore, whether Systems Thinking theory, interactive simulation, or both, offer the best learning outcomes for sustainability education, is also an important question. A randomised controlled study found that simulation alone significantly increased sustainability learning outcomes. Simulation, together with systems archetypes, was also found to significantly support transfer of understanding from one problem to another with a similar systemic structure, although at a lower level of confidence.

education for sustainable development | ESD | systems thinking | system dynamics | simulation | transfer of skills | randomised controlled trial | RCT | system archetypes

1. Systems and Systems Thinking

A system is a complex collection of parts interacting to create often counter-intuitive dynamic behaviour[1]. Humans struggle to reason about complex systems[2][3]. Systems thinking is a skill set and a way of thinking that equips people to understand dynamic complexity[4].

2. Sustainability and Sustainability Education

The concept of sustainability is complex and is often used in an imprecise[5] or even misleading[6] way. Tracing the origins of the term, since the 1980s the UN has been instrumental in developing the related concepts of sustainability, sustainable development and sustainability education. It founded the World Commission on Environment and Development (WCED) in 1980 which was responsible for the influential 1987 Brundtland Report[7]. The definition of sustainability in that report is the one most frequently quoted, namely that 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

The UN also led efforts to formulate concrete targets for action towards sustainability. In 2000, the UN defined the eight Millennium Development Goals (MDGs) for 2015, of which goal seven was ‘To ensure environmental sustainability’. The MDGs were developed further in the 17 Sustainable Development Goals (SDGs), set in 2015 and to be achieved by 2030, and adopted by all 193 United Nations member states.

The UN adopted the Decade of Education for Sustainable Development (DESD) from 2005 to 2014. Education for Sustainable Development (ESD) is explicitly recognized in the SDGs as part of Target 4.7 of the SDG on education. It is seen as ‘crucial for the achievement of sustainable development’[8]. The Council of the European Union sees ESD as ‘essential for the achievement of a sustainable society and is therefore desirable at all levels of formal education and training, as well as in non-formal and informal learning’ (Council conclusions on education for sustainable development. https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/educ/117855.pdf, accessed on 9 June 2021). Thus, ESD is seen as a form of lifelong learning, and necessary for all citizens. It underpins public participation in environmental and developmental decision making[9].

Sustainability education seeks to address the considerable challenge of training learners not only to solve or understand existing complex problems, but also to equip them with skills that they can transfer to new problems as they arise. In the last few years, there has been an urgent call for innovative sustainability pedagogies[10](p. 58).

O’Flaherty and Liddy provide a useful summary of the approaches so far taken in ESD, including blended learning, drama, simulation exercises, multi-media, problem-based learning and discussion forums[11]. They describe methodological and pedagogical questions that remain open and highlight the need for assessment frameworks and formal trials for evaluating the effectiveness of different approaches to ESD.

3. The Need for Systems Thinking in Sustainability Education

Sustainability education is an emerging field. In her review, Maria Hofman-Bergholm explores reasons for problems with its implementation[12]. She finds that systems thinking is required to comprehend the intricate connections in sustainable development[13] (p. 27). Complex reasoning skills must be taught, as they are not inherent. Humans have well-known limitations in cognitive ability to reason about complex systems that must be overcome[14].

According to Frisk and Larson, sustainability education will only be effective if it incorporates systems thinking, long-term thinking, collaboration and engagement, and action orientation[15]. Sustainability, they say, is fundamentally a call to action, and sustainability education therefore requires experiential, practical and flexible learning methods.

According to Wiek et al., ‘Sustainability education should enable students to analyse and solve sustainability problems’[16] (p. 204). This requires a particular set of interlinked and interdependent key competencies. Wiek et al. review the literature and identify five key competencies, the first being systems thinking competence (the others are anticipatory, normative, strategic and interpersonal competence).

According to Soderquist and Overakker, the discipline of systems thinking provides a process, set of thinking skills and 'technologies' that can improve the systemic understanding that is required for sustainability education[17]. These include stock and flow mapping, computer simulation, and simulation-based learning environments. They claim that simulation-based learning environments build mental simulation capacity, if they are designed carefully.

Cavana and Forgie describe a number of well-established systems education programs and review teaching approaches for sustainability education[18]. They explore the strong links between systems approaches and sustainability goals, illustrating that the two are so entwined as to be inseparable. They describe the need for, and the lack of, simulation-based learning environments for systems thinking-orientated sustainability education.

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