

REVIEW ARTICLE OPEN ACCESS

# Education for Problems of Sustainable Development

Abbas Ziafati Bafarasat 

School of the Built Environment, Oxford Brookes University, Oxford, UK

**Correspondence:** Abbas Ziafati Bafarasat ([aziafati-bafarasat@brookes.ac.uk](mailto:aziafati-bafarasat@brookes.ac.uk))**Received:** 20 September 2025 | **Revised:** 10 January 2026 | **Accepted:** 9 February 2026**Keywords:** cognitive | competencies | complex problems | Cynefin framework | education | multiple intelligences | problem-based learning | sustainable development

## ABSTRACT

The Cynefin framework for decision-making categorizes problem environments into simple (known knowns), complicated (known unknowns), complex (unknown unknowns), and chaotic (unknowables). Simple and complicated problem environments enable best and good solutions, but complex and chaotic problem environments require emergent and novel solutions. Arguing that sustainability problems are complex and chaotic, this study applies the Cynefin framework of decision-making in complex and chaotic problem environments as a lens for sensemaking and reframing of sustainability competencies, resulting in proposing a suite of sustainability competencies to address complex and chaotic problems. Five competencies are proposed and defined, including: reflective action, critical systems thinking, boundary spanning, active empathy, and pathfinding. These are the first suite of sustainability competencies that are problem-based, processual, and integrated in nature, involving a sequential relationship between the competencies grounded on the Cynefin problem-solving steps. This enables systematic learning of these competencies in a single instructional project, hence facilitating deep relational learning. Furthermore, the study proposes an instructional design that situates learning of these competencies in human cognitive architecture to reduce extraneous cognitive load on the limited working memory and encourage long-term memory construction. The study hypothesizes that each competence is best learned through a tailored set of the nine human intelligences identified by the theory of multiple intelligences. For example, the competence of critical systems thinking, defined as the ability to account for known, unknown, and unknowable relationships in a problem context, is best learned through logical-mathematical intelligence and spatial intelligence—which help analyze known problem relationships, naturalistic intelligence—which helps reflect on unknown problem relationships, and existential intelligence which helps consider unknowable problem relationships.

## 1 | Introduction

The United Nation's (2025, 2) Sustainable Development Goals Report finds that “only 35 per cent of SDG targets are on track or making moderate progress. Nearly half are moving too slowly and, alarmingly, 18 per cent are in reverse.” Ziafati Bafarasat et al. (2025) in this context highlight shortcomings of sustainability education to adopt a problem-based approach and prepare learners for messy real challenges in personal and professional situations.

Following the proclamation of the United Nations Decade of Education for Sustainable Development (2005–2014), studies about sustainability competencies have been on a steep rise. Competency is defined as “an integrated set of knowledge, skills and attitudes to successfully perform tasks in authentic environments” (Ziafati Bafarasat et al. 2025, n.p.). These studies have identified competencies needed to capacitate learners to become change agents and take action—as professionals, decision-makers and citizens, for example, to end poverty and combat inequalities and marginalization; to address health risks

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

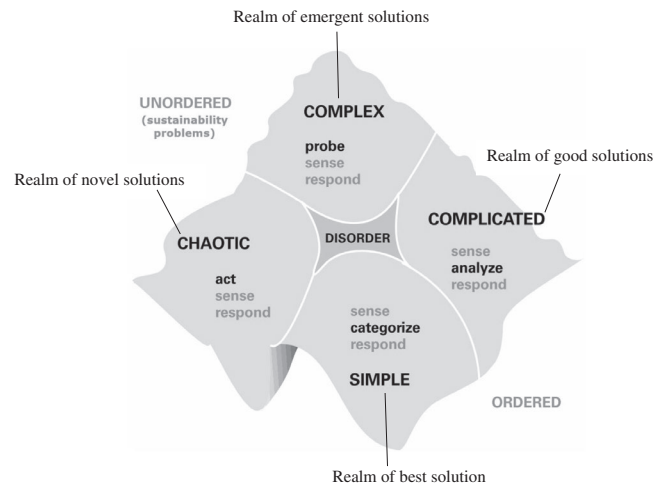
© 2026 The Author(s). *Sustainable Development* published by ERP Environment and John Wiley & Sons Ltd.

and promote wellbeing; to confront economic problems; and to address climate change and other environmental challenges, and to do so with a holistic perspective (Brundiens et al. 2021; Lambrechts and Van Petegem 2016; Price et al. 2024; Salonen and Siirilä 2019; United Nations 2015).

As studies in this field mature, Bianchi (2020, 51) notes, “there is a high degree of convergence among scholars, and between academic and grey literature, on what key competences in sustainability are.” However, there is a lingering critique that by focusing on compartmentalized abilities, sustainability competencies struggle in whole-of-learner development for real problem contexts (Elliot 2007; Lotz-Sisitka and Raven 2009; Mochizuki and Fadeeva 2010; Ziafati Bafarasat et al. 2025). Some note “shallow or inadequate interpretations of the competence framework” (Lotz-Sisitka and Raven 2009, 317) that fail to approach sustainability learning with a systematic problem-based perspective (Sinakou et al. 2022). Subsequent research reiterates these limitations of sustainability education, particularly focusing on the need to tailor competencies to different stages and aspects of problem solving (Michel et al. 2023; Torsdottir et al. 2024). Beagon et al. (2023) believe that one way to address these critiques and turn education into a real game changer for sustainable development is to focus on a suite of broad competencies tailored to the process of addressing sustainability problems. Bianchi (2020) and Ziafati Bafarasat et al. (2025) call for a “suite” of competencies which enable learners to address real problems of sustainability in their entirety, including different stages and aspects of these problems. Wiek and his colleagues tried to address this gap by adding a new competence, entitled meta-competence, which involves using and interlinking their other five key competencies to solve sustainability problems (Wiek et al. 2016). However, this does not change the nature of their competencies or interlink them by nature in a process of problem solving.

Asking what suite of competencies enable learners to address complex and chaotic problems of sustainable development, the present study aims to fill this gap through recombining evidence from the literature in a methodology of “sensemaking and reframing” resulting in novel conceptual findings and some supporting instructional hypotheses that will follow. The study also situates its significance in debates about a new sense of purpose for universities, focusing on enabling learners to: (a) address wicked problems in real life and professional situations (Ramaley 2014), and (b) serve the goals of sustainable development (Shephard 2015). These two missions are interrelated. Sustainability problems are viewed as wicked or complex and chaotic; even some view sustainable development as a wicked problem because of its many interdependent factors with contradictory and changing requirements making them seem impossible to solve (Murphy 2012).

The Cynefin [a Welsh word for habitat] framework created by Dave Snowden (Snowden 2002, 2010; Snowden and Boone 2007) categorizes problem environments in a spectrum of simple, complicated, complex, and chaotic according to growing difficulty and confusion. As Figure 1 indicates, simple problem environments are defined by their stability and clear cause-and-effect links that are apparent to all. This is the realm of “known knowns.” It is possible for decision-makers to explore the best

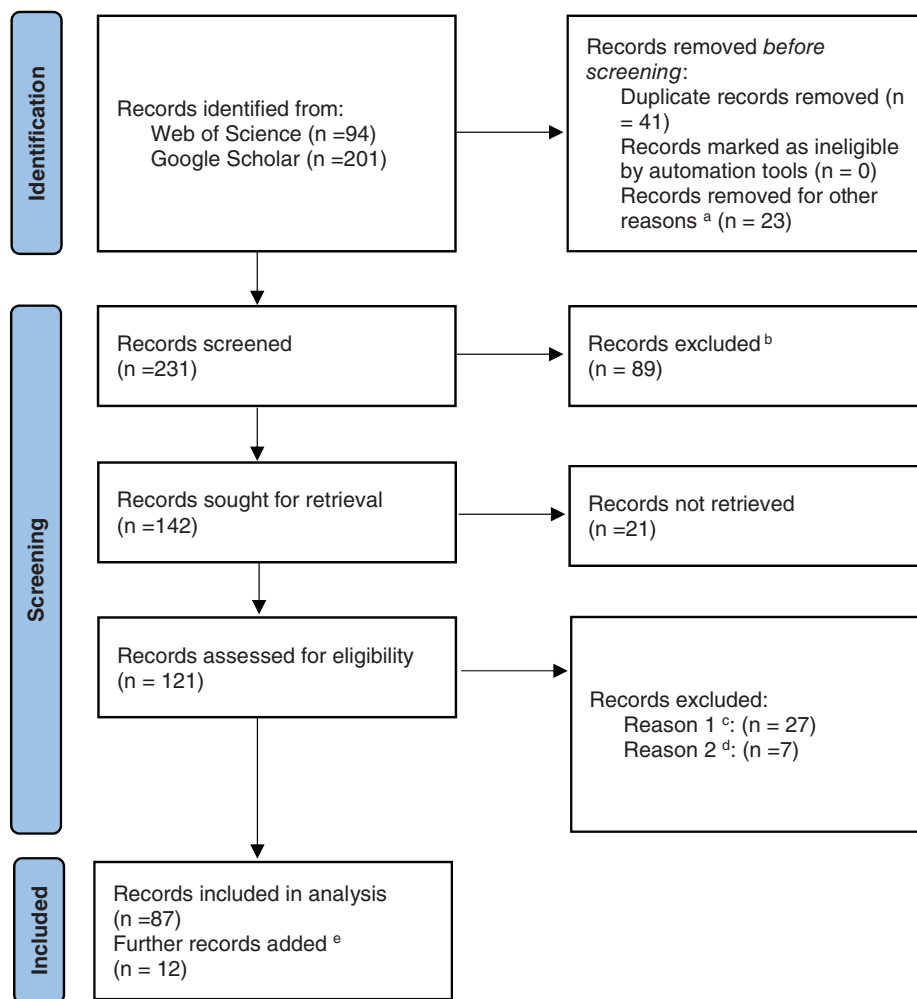


**FIGURE 1** | Problem environments in the Cynefin framework (Reconfigured from: Snowden and Boone 2007, 4).

solution to these problems. This requires that decision-makers first assess the facts of the situation or “sense” them, and then categorize facts and respond to them. Complicated problem environments may offer several correct answers, and while a clear cause-and-effect relationship exists, it may not be visible to everyone. They represent the realm of “known unknowns.” While decision-makers cannot find the best solution to complicated problems, it is possible to find good solutions. Addressing complicated problems requires decision-makers to sense them, analyze relationships, and then respond to these problems.

In a complex problem environment, right answers cannot be easily uncovered; instead, helpful patterns can emerge if decision-makers engage in experiments that are safe to fail. This is the realm of “unknown unknowns,” and emergent solutions which require decision-makers to experiment first, then sense, and finally respond. In a chaotic context, seeking right answers is futile. The cause-and-effect relationships are impossible to identify because they are in constant flux. This is the realm of “unknowables,” rapid action, and novel solutions. In this context, the required immediate job is “is not to discover patterns but to stanch the bleeding” (Snowden and Boone 2007, 5). Addressing chaotic problems requires decision-makers to first take action to create order, identify areas of stability, and then work to shift the situation from chaos to complexity. The fifth context, disorder, is applicable when it is uncertain which of the other four contexts is dominant, hence requiring decision-makers to break down the situation and assign each resulting component part to one of the other four realms (Snowden 2011; Snowden and Boone 2007).

Sustainable development emphasizes the social dimension of human needs, the environmental dimension, and the imperative to preserve the ecosystem ability to provide services in the future (Spangenberg 2014; Ziafati Bafarasat et al. 2023). It sets a path of contradictions with “unknown unknowns” and “unknowables” for our capacities, meaning that its problem contexts are complex and chaotic, with emergent relationships and discontinuous transitions that are difficult or impossible to uncover (Caskey and Williams 2025; Scoones et al. 2007; Wiek et al. 2011). Addressing these problems, which extend across various



<sup>a</sup> Only abstract available in English

<sup>b</sup> Excluded in abstract screening for relevance and similarity

<sup>c</sup> Studies not peer reviewed (e.g., preprints)

<sup>d</sup> Chapters reproduced from included papers

<sup>e</sup> Reports / books from international educational bodies and stakeholder organizations

**FIGURE 2** | PRISMA 2020 flow diagram of scoping the literature about sustainability competencies (Author, template from: PRISMA 2024; <https://www.prisma-statement.org/prisma-2020-flow-diagram>).

domains, timescales, levels, and geographies (Lambrechts and Van Petegem 2016; Ziafati Bafarasat and Pugalis 2020), according to the Cynefin framework requires following the trio of steps for emergent and novel problem solving—that is “act/probe – sense – respond.” Section 2 explains a methodology of “sensemaking + reframing” of sustainability competencies according to these Cynefin problem-solving steps in order to arrive at an integrated and processual suite of sustainability competencies for complex and chaotic problems. Section 3 presents the results of this, and Section 4 provides the second novel contribution of this study suggesting tailored cognitive instruction of the proposed competencies through focusing on particular intelligences to deep learn each competence. Section 5 provides the conclusions of the study and their implications for future practice and research about sustainability learning.

## 2 | Methodology: Sensemaking + Reframing

The methodology of this study is called ‘sensemaking + reframing’—a process of knowledge recombination first introduced by Ziafati Bafarasat et al. (2025) to integrate evidence between different fields that have similar ontological and epistemological foundations. To administer this methodology, at first a scoping review of the literature about competencies for sustainable development was conducted with the search, identification, screening, and inclusion of records according to the JBI scoping review guidelines (Aromataris et al. 2024) and PRISMA-ScR checklist (see Tricco et al. 2018) as reported in Figure 2. As Figure 2 indicates, a search string of *sustainability* OR *sustainable development* AND *competency* OR *competence* OR *competencies* OR (*skill* AND *knowledge and values*

**TABLE 1** | The analytical process of sensemaking + reframing (Author's illustration).

	Sensemaking of sustainability competencies (deductive analysis)	Reframing of sustainability competencies (inductive analysis)
Steps to address complex and chaotic problems in the Cynefin framework (Snowden 2010, 2011; Snowden and Boone 2007)	<ol style="list-style-type: none"> <li>1. Act/probe: Act to stop immediate harm/engage in experiments that are safe to fail (Snowden and Boone 2007)</li> <li>2. Sense: Assess relationships in the problem context (Snowden and Boone 2007)</li> <li>3. Respond: Solve problems in contextually appropriate ways (Snowden and Boone 2007)</li> </ol>	

OR *attitudes* OR *ethics*) resulted in identifying 94 records from Web of Science and 201 from Google Scholar. Identification of records was based on a principle of “saturation” (see Ziafati Bafarasat 2021; Ziafati Bafarasat and Sharifi 2024). In other words, records returned in these web search platforms were sorted by relevance, and all records from the first one until three consecutive records that had less relevant titles were identified to proceed to the next screening step. Figure 2 indicates that the screening process undertaken on these records resulted in their reduction to 87 records. These records were supplemented manually with 12 records from stakeholder organizations, meaning that 99 records entered the analytical process of sensemaking + reframing to identify a suite of problem-based competencies for sustainable development as shown in Table 1.

Sustainability competencies were identified and summarized from the included records. They were then analyzed deductively (Table 1) according to the Cynefin framework for complex and chaotic problems (Snowden 2010, 2011; Snowden and Boone 2007). In this sensemaking process, 16 sustainability competencies were included and defined, but a subsequent comparative analysis merged similar competencies, resulting in 10 sustainability competencies corresponding with the Cynefin framework. After this deductive analysis, the 10 competencies underwent inductive analysis intended to reframe them as a suite of competencies to address complex and chaotic problems of sustainable development. This resulted in five integrated and processual competencies presented in the next section as a novel contribution of this study.

### 3 | A Suite of Competencies to Address Complex and Chaotic Problems of Sustainability

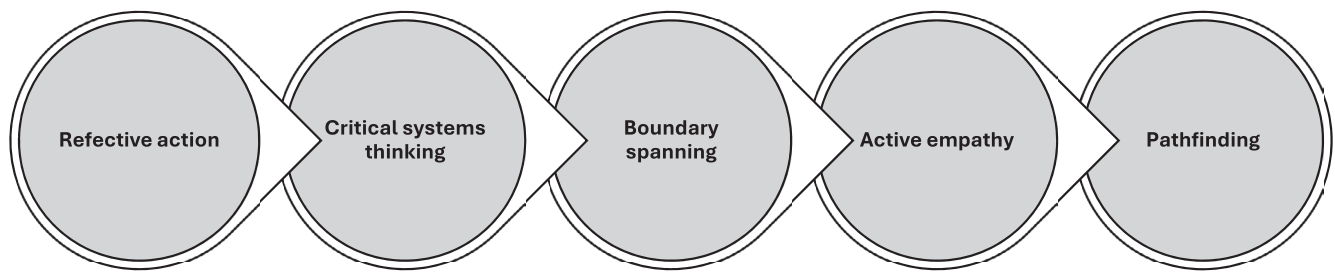
Table 2 includes the findings of deductive-inductive analyses undertaken toward an integrated, processual suite of competencies for complex and chaotic problems of sustainability. The resulting competencies, which are broad to support situated elaboration and local discretion, are termed and defined by this study as follows:

- i. *Reflective action*: the ability to design and drive, after consideration of multiple options, small fixes to urgent sustainability problems, and reflect on their outcomes;
- ii. *Critical systems thinking*: the ability to account for known, unknown, and unknowable relationships in a problem context;
- iii. *Boundary spanning*: the ability to cross technical, cultural, disciplinary, and professional boundaries to cooperate in a problem context;
- iv. *Active empathy*: the ability to stand for (silent) sufferers of sustainability problems; and
- v. *Pathfinding*: the ability to provide anticipatory solutions for evolving sustainability problems before they fully manifest

This suite of five proposed competencies addresses two main gaps in the literature. Firstly, in contrast to previous studies about sustainability competencies, they are situated in complex and chaotic problems that are defining features of sustainable development. Secondly, these five competencies are not a set of distinct abilities as in other sustainability competencies; by contrast, these five competencies are both integrated and processual, corresponding to the Cynefin sequential steps (Snowden 2010, 2011; Snowden and Boone 2007) in addressing complex and chaotic problems (Figure 3). While reflective action emphasizes the ability to act swiftly but cautiously on urgent sustainability problems despite knowledge barriers in complex and chaotic environments, critical systems thinking and boundary spanning focus on expanding perspectives and cooperation to address unknowns in the problem environment and account for unknowables. Active empathy applies the insights and networks achieved in this process to stand for sufferers of sustainability problems, including in pathfinding. Pathfinding provides strategic solutions for known and unknown sustainability problems in an emergent context. The processual nature of these competencies enables their consolidation into a single instructional project. To further support deep relational learning of these competencies for different learning communities and intelligence profiles, the next section suggests their tailored cognitive instruction, providing a hypothetical method based on human cognitive architecture.

**TABLE 2** | Findings of sensemaking + reframing of sustainability competencies according to the Cynefin framework (Author's illustration).

	<b>Sensemaking of sustainability competencies according to the Cynefin steps</b>	<b>Reframing of sustainability competencies</b>
Steps to address complex and chaotic problems in the Cynefin framework (Snowden 2010, 2011; Snowden and Boone 2007)	<p>1. Act/probe: Act to stop immediate harm/engage in experiments that are safe to fail (Snowden and Boone 2007)</p> <p>2. Sense: Assess relationships in the problem context (Snowden and Boone 2007)</p>	<p>1. Reflective action: the ability to design and drive, after consideration of multiple options, small fixes to urgent sustainability problems, and reflect on their outcomes</p> <p>2. Critical systems thinking: the ability to account for known, unknown, and unknowable relationships in a problem context</p> <p>3. Boundary spanning: the ability to cross technical, cultural, disciplinary, and professional boundaries to cooperate in a problem context</p> <p>4. Active empathy: the ability to stand for (silent) sufferers of sustainability problems</p> <p>5. Pathfinding: the ability to provide anticipatory solutions for evolving sustainability problems before they fully manifest</p>
	<p>– Ability to engage with real world challenges (Batsa et al. 2025; Frisk and Larson 2011; Hammer and Lewis 2023; Lambrechts et al. 2013; Lans et al. 2014; Lozano et al. 2017; Mochizuki and Fadeeva 2010; Rieckmann 2012; Sleurs 2008; Willard et al. 2010; Ziafati Bafarasat et al. 2025)</p> <p>– Ability to design actions, implement and reflect (Brundiers et al. 2021; De Haan 2006; Hammer and Lewis 2023; Krüger et al. 2025; Lambrechts et al. 2013; Redman and Wiek 2021; Roorda 2010; Rychen 2003; Venn et al. 2022; Willard et al. 2010)</p> <p>– Ability to perceive individual parts as components of larger, interconnected wholes (systems thinking) (Amprazis and Papadopoulou 2025; Brundiers et al. 2021; Evans 2019; Frisk and Larson 2011; Ghorbani and Mirshah Jafari 2025; Günther et al. 2024; Lambrechts et al. 2013; Lans et al. 2014; Lozano et al. 2017; Mochizuki and Fadeeva 2010; Redman and Wiek 2021; Rieckmann 2012; Roorda 2010; Sleurs 2008; Svanström et al. 2008; Tilbury and Wortman 2004; UNESCO 2017; Wiek et al. 2011; Willard et al. 2010; Ziafati Bafarasat et al. 2025)</p> <p>– Ability to question visible facts and relationships (critical thinking) (Amprazis and Papadopoulou 2025; De Haan 2006; Evans 2019; Ghorbani and Mirshah Jafari 2025; Günther et al. 2024; Krüger et al. 2025; Lozano et al. 2017; Rieckmann 2012; Svanström et al. 2008; Tilbury and Wortman 2004; UNESCO 2017)</p> <p>– Communication and cooperation skills (interpersonal competence) (Amprazis and Papadopoulou 2025; Brundiers et al. 2021; de Kraker et al. 2007; Elmose and Roth 2005; Evans 2019; Frisk and Larson 2011; Ghorbani and Mirshah Jafari 2025; Günther et al. 2024; Hammer and Lewis 2023; Krüger et al. 2025; Lans et al. 2014; Lozano et al. 2017; Redman and Wiek 2021; Rieckmann 2012; Rychen 2003; Svanström et al. 2008; Venn et al. 2022; Wiek et al. 2011; Willard et al. 2010; Ziafati Bafarasat et al. 2025)</p> <p>– Ability to collaborate with other disciplines (interdisciplinary competence) (Batsa et al. 2025; De Haan 2006; de Kraker et al. 2007; Evans 2019; Günther et al. 2024; Lambrechts et al. 2013; Lozano et al. 2017; MacDonald and Shriberg 2016; Rieckmann 2012; Tilbury and Wortman 2004; UNESCO 2017)</p> <p>– Ability to be affected by sustainability issues (Amprazis and Papadopoulou 2025; De Haan 2006; Evans 2019; Günther et al. 2024; Lambrechts et al. 2013; Lans et al. 2014; Lozano et al. 2017; Mochizuki and Fadeeva 2010; Rieckmann 2012; Roorda 2010; Sleurs 2008; UNESCO 2017; Wiek et al. 2011; Ziafati Bafarasat et al. 2025)</p> <p>– Ability to act in solidarity with those unable to control their conditions (Brundiers et al. 2021; Elmose and Roth 2005; Ghorbani and Mirshah Jafari 2025; Lambrechts et al. 2013; Lans et al. 2014; Lozano et al. 2017; Redman and Wiek 2021; Rieckmann 2012; Ziafati Bafarasat et al. 2025)</p> <p>– Ability to craft and evaluate rich pictures of a sustainable future (foresighted competence) (Amprazis and Papadopoulou 2025; Brundiers et al. 2021; De Haan 2006; Frisk and Larson 2011; Günther et al. 2024; Lambrechts et al. 2013; Lans et al. 2014; Lozano et al. 2017; Redman and Wiek 2021; Rieckmann 2012; Roorda 2010; Tilbury and Wortman 2004; UNESCO 2017; Wiek et al. 2011; Ziafati Bafarasat et al. 2025)</p> <p>– Ability to design and drive adaptive transformations (strategic competence) (Amprazis and Papadopoulou 2025; Brundiers et al. 2021; Evans 2019; Günther et al. 2024; Krüger et al. 2025; Redman and Wiek 2021; UNESCO 2017; Venn et al. 2022; Wiek et al. 2011; Willard et al. 2010; Ziafati Bafarasat et al. 2025)</p>	
3. Respond: Solve problems in contextually appropriate ways (Snowden and Boone 2007)		



**FIGURE 3** | The five problem-based competencies for sustainable development are processual, enabling instructors to integrate them in a single learning project (Author's illustration).

#### 4 | Learning of the Sustainability Competencies Through Multiple Intelligences

This study suggests deep learning of the proposed competencies by situating their instruction in human cognitive architecture as explained by cognitive load theory. Cognitive load theory has been in continuous development since the 1980s, with new details and critiques following empirical tests, but basic principles of the theory about human cognitive architecture and their implications for instructional design remain valid (Ngandoh et al. 2025; Sweller 2023, 2024; Zou et al. 2025). Sweller (2023, 17) in this context notes that: “A major contribution of cognitive load theory has been to alert the field of instructional design to some very basic and very well-known characteristics of human cognition.”

The theory holds that the design of learning activities should understand, accommodate, and align the learner's cognitive system, the learning material, and interactions between both (Schmidt et al. 2007). Cognitive load theory is, in particular, concerned with complex learning material where learners are overwhelmed by the number of information elements and their interactions (Paas et al. 2004). The theory argues that human cognitive architecture consists of two main components, including (i) a working memory which is responsible for processing and learning of new information but is very limited—both in the number of elements it can process and its duration, and (ii) an unconscious, unlimited long-term memory which stores well-learned material handled earlier by the working memory (Jiang 2024; Sweller et al. 1998). In other words, all new information is initially processed by the working memory and, if learned well, is then stored in the long-term memory for later use (Sweller et al. 2019). Long-term memory stores knowledge of mechanisms or board configurations and the appropriate actions associated with those configurations, hence supporting expertise or high-skill abilities (Jiang 2024; Sweller 2003).

Cognitive load theory suggests that to stimulate interest, depth, and stability in learning, instructional designs should explore ways to reduce working memory load while supporting long-term memory construction (Sweller 2024; Sweller et al. 1998). Sweller et al. (1998) identify three types of cognitive load, including intrinsic, extraneous, and germane. From these, intrinsic cognitive load cannot be changed by instructional interventions because it is intrinsic to the material to be learned, but extraneous cognitive load is unnecessary cognitive load and should be reduced by instructional interventions. Germane cognitive

load, created through learning activities like asking students about examples or making examples incomplete so that students have to complete them, supports long-term memory construction and should be increased if total cognitive load is not excessive for the limited working memory (Klepsch and Seufert 2020; Sweller 2024; Sweller et al. 1998).

Education for sustainable development creates high intrinsic load due to high element interactivity in the information that needs to be processed for learning. According to Sweller (2003, 216), when element interactivity is high in the learning content, it means “all of the information with its multiple elements must be processed simultaneously, imposing a heavy cognitive load.” Learners might respond to high cognitive load by rote learning as observed by some studies about instructing content related to sustainable development (Khalid Malik et al. 2022; Murtaza and Maqbool 2024). Sweller (2003) argues that the reason rote learning of highly interactivity material occurs more often is because learning of individual elements without learning their relations can reduce cognitive load dramatically. Education for sustainable development should therefore decrease extraneous cognitive load as much as possible through instructional design to support the high intrinsic cognitive load involved in learning, and, where total cognitive load allows, increase germane cognitive load.

Sweller et al. (1998) argue that a fundamental strategy to reduce extraneous cognitive load is to increase sensory input channels in learning, hence reducing interference of information and pressure on the working memory to process relational information in a single channel (see also Mayer 2024; Reed 2006; Sorden 2005; Surbakti et al. 2024). Paivio's (1986) dual-coding theory, subsequently supported by empirical evidence (Paivio 2014a; Wooten and Cuevas 2024), identifies two sensory input channels in the working memory, one verbal and the other nonverbal (including appearance, smell, touch., etc.) (Paivio 2014b). Baddeley (1986) argues that effective working memory capacity can be increased by using these two channels together in multimedia instruction rather than using one or the other alone (Sorden 2005). For example, Mayer (2001) found that students learn complex information better from animation and narration than from animation and on-screen text as the former reduces interference of information and hence extraneous cognitive load by using both sensory channels. Mayer's (2001, 2022, 2024) cognitive theory of multimedia learning similarly emphasizes instructional integration of both sensory channels.

This study argues that instructional applications of cognitive load theory and dual-coding theory are best unleashed in integration by using the theory of multiple intelligences. The theory of multiple intelligences was first developed by Howard Gardner (1983) in his book *Frames of Mind* after years of his study and observation on gifted and handicapped children (see also Bas 2016). His theory challenged the classic notion of intelligence in several ways, but most importantly, it argued that several relatively autonomous intelligences are at work, not just verbal and logical intelligences, and that individuals have different strengths and weaknesses in their intelligences profile (Gouws 2007; Sithara 2025). The theory, empirically supported by neuroscientific studies (Shearer and Karanian 2017), identifies nine forms of talents or intelligences, including verbal–linguistic, logical–mathematical, spatial, musical, bodily–kinesthetic, naturalistic, existential, interpersonal, and intrapersonal intelligence as defined in Table 3 (Chikezie 2024; Gardner and Hatch 1989). The theory of multiple intelligences

**TABLE 3** | Nine intelligences in the theory of multiple intelligences (Author's illustration, based on McClellan and Conti 2008, 15).

Intelligence	Definition
Verbal–linguistic	“the ability to understand, use, and manipulate written or spoken words productively”
Logical–mathematical	“the elevated skill of manipulating and understanding numbers and the ability to reason effectively”
Musical	“the ability to appreciate, distinguish, compose, and perform in various musical forms”
Spatial	“being able to see an image or situation and quickly assess areas that could be changed to transform or improve the appearance”
Bodily–kinesthetic	“the proficiency of using the entire body to express ideas and feelings and the competence of using the body to produce or transform things”
Intrapersonal	“knowing oneself and acting to modify oneself based on that knowledge”
Interpersonal	“the proficiency of an individual in perceiving the moods, aims, motivations, and emotions of others”
Naturalistic	“the ability to appreciate, categorize, classify, explain, and connect to things encountered in nature”
Existential	“the appreciation of spirituality and understanding questions about life. This intelligence relates to exploring human existence in the universe”

advocates for individual-centered education which helps learners develop the intelligences they are weaker in and takes instructional advantage of the intelligences in which they are stronger (Gardner 1983, 2008; Gray and Waggoner 2002; Khan et al. 2025). This means that the teacher should integrate intelligence modalities in the classroom, continuously shifting in this integration to support different profiles of intelligences (Bas 2016; Phillips 2010). Shifts to intelligence modalities in which students are stronger support learning of high interactivity material, and shifts to intelligence modalities in which students are weaker focus on learning simple or low interactivity information.

The theory of multiple intelligences has three important implications for designing cognitive instruction with direct relevance to sustainability education which causes high intrinsic load. The first is increasing the menu of learning modalities and providing nine options to choose and blend in spreading learning to the verbal and nonverbal channels in the working memory, hence enabling flexibility in reducing extraneous cognitive load while remaining focused on the concepts that need to be learned, “rather than trying too much to entertain” (Sorden 2005, 265). The second implication, this study argues that, is to reduce extraneous cognitive load beyond the mechanism of distributing learning modalities between the verbal and nonverbal channels as suggested by cognitive load theory, and that is through tailoring of learning modalities to specific intelligences profiles of learners. The third implication, which is hypothesized in this study, is to reduce extraneous cognitive load and support long-term memory construction by tailoring learning modalities to intended learning outcomes. This hypothetical contribution is explained below for tailored modalities learning of the five sustainability competencies identified in the previous section.

Table 4 hypothesizes what intelligences best support learning of each of the five problem-based competencies for sustainability, and how. This is situated in a context where very few studies are available about the relationships between multiple intelligences and sustainability learning outcomes. Cuadrado-Ballesteros et al. (2025), for example, find in their study that the most frequently engaged intelligences in a sustainability learning project were interpersonal, intrapersonal, linguistic–verbal, and spatial, but configurations of the most supportive intelligences showed some small variations between different themes of sustainability learning—for example, learning gender equality was best supported by verbal–linguistic; intrapersonal, and intrapersonal intelligences. Güven and Uyulgan (2021) observe that bodily–kinesthetic intelligence and spatial intelligence better support learning of ecological awareness, and Tabassum et al. (2024) highlight the role of intrapersonal intelligence in the competence of digital literacy. Reviewing the literature about the roles of multiple intelligences in learning managerial competence, D'Silva and Pande (2025, 1450) note that “MI [multiple intelligences] and managerial competence have been widely studied in isolation, their integration remains significantly underrepresented, accounting for only ~0.015% of published research.”

As Table 4 indicates, the competence of active empathy is well learned through all of the nine intelligences, suggesting that it is easier for learners with various intelligence profiles to acquire. However, from these intelligences, some best support learning of “being affected” due to enhancing other-related emotional reactions involved in feeling what the other person is experiencing

**TABLE 4** | Tailored learning of the problem-based sustainability competencies through multiple intelligences (Author's hypothetical reflections—last column based on Nicholson-Nelson 1998).

<b>Problem-based sustainability competencies</b>	<b>Most supportive intelligences</b>		<b>Learning activities</b>
1. Reflective action (the ability to design and drive, after consideration of multiple options, small fixes to urgent sustainability problems, and reflect on their outcomes)	Verbal-linguistic intelligence	– Engaging with evidence about problems – Discussing and debating problems	Learning activities involving reading, hearing, speaking, writing, discussing, and debating
	Logical-mathematical intelligence	– Classifying problems and responses – Reflecting on options before and after action – Analyzing problem relationships	Learning activities involving working with patterns and relationships, classifying, categorizing, etc.
	Spatial intelligence	– Identifying areas in need of intervention – Assessing areas affected by problems and interventions	Learning activities involving working with pictures, maps, visualizing, drawing, etc.
	Interpersonal intelligence	– Understanding feelings, interests, and objectives of problem stakeholders	Learning activities involving interviewing, group projects, interdisciplinary collaboration, etc.
	Naturalistic intelligence	– Considering problems and reflecting on fixes in connection with ecosystems and their services	Learning activities which involve working in nature, exploring living things, plants, and natural events, etc.
2. Critical systems thinking (the ability to account for known, unknown, and unknowable relationships in a problem context)	Logical-mathematical intelligence	– Analyzing known problem relationships	ME <sup>a</sup>
	Spatial intelligence		ME
	Naturalistic intelligence	– Reflecting on unknown problem relationships	ME
	Existential intelligence	– Considering unknowable problem relationships	Learning activities involving reflection on life purpose and path
3. Boundary spanning (the ability to cross technical, cultural, disciplinary, and professional boundaries to cooperate in a problem context)	Interpersonal intelligence	– Adapting to different perspectives, languages, and frameworks of problem stakeholders	ME
	Intrapersonal intelligence		Learning activities involving self-paced and self-reflecting work
	Verbal-linguistic intelligence		ME
	Musical intelligence		Learning activities involving composing and performing, singing, etc.
4. Active empathy (the ability to stand for (silent) sufferers of sustainability problems)	Intrapersonal intelligence	– Being affected by sustainability problems	ME
	Existential intelligence		
	Naturalistic intelligence		
	Bodily-kinesthetic intelligence		Learning activities involving touching, moving, smelling, role-playing, etc.
	Interpersonal intelligence	– Acting in solidarity with sufferers of sustainability problems	ME
	Verbal intelligence		
	Logical-mathematical intelligence		
	Spatial intelligence		
Musical intelligence			

(Continues)

TABLE 4 | (Continued)

Problem-based sustainability competencies	Most supportive intelligences		Learning activities
5. Pathfinding (the ability to provide anticipatory solutions for evolving sustainability problems before they fully manifest)	Logical-mathematical intelligence Verbal-linguistic intelligence Interpersonal intelligence Spatial intelligence Naturalistic intelligence Existential intelligence	– Crafting long-term strategies for sustainability problems    – Situating strategies in uncertainty and emergence	ME

<sup>a</sup>Mentioned earlier.

and creating affective cognitive traces which resonate in subsequent experiences (Versace et al. 2009; Wagner et al. 2015), whereas the other intelligences best support learning of full empathy as “being affected and acting in solidarity.” The competencies of critical systems thinking and boundary spanning are best learned through four intelligences, such as naturalistic, existential, musical, and spatial intelligences. These competencies are therefore difficult for a wider range of intelligence profiles, hence requiring more focus in learning these competencies on distributing information across the verbal and nonverbal channels. The competence of reflective action is best learned through five intelligences, from the commonly used verbal-linguistic and logical-mathematical intelligences to naturalistic and spatial intelligences, hence accommodating a wider range of personal talents profiles. The competence of pathfinding, or the ability to provide preventive solutions for known and unknown sustainability problems, involves learning very high interactivity content, but it is best supported by six intelligences, suggesting it is possible for most intelligence profiles to engage with despite the competence requiring dealing with long-term uncertainties.

## 5 | Conclusions

The Cynefin framework for decision-making categorizes problem environments into simple (known knowns), complicated (known unknowns), complex (unknown unknowns), and chaotic (unknowables). Simple and complicated problem environments enable best and good solutions, but complex and chaotic problem environments require emergent and novel solutions. Arguing that sustainability problems are complex and chaotic, this study applied the Cynefin framework of decision-making in complex and chaotic contexts as a lens for sensemaking and reframing of sustainability competencies, resulting in proposing a suite of sustainability competencies to address complex and chaotic problems. Five competencies were proposed and defined, including reflective action, critical systems thinking, boundary spanning, active empathy, and pathfinding.

Reflective action is the ability to design and drive, after consideration of multiple options, small fixes to urgent sustainability problems, and reflect on their outcomes. Critical systems

thinking is the ability to account for known, unknown, and unknowable relationships in a problem context. Boundary spanning is the ability to cross technical, cultural, disciplinary, and professional boundaries to cooperate in a problem context. Active empathy is the ability to stand for (silent) sufferers of sustainability problems. Pathfinding is the ability to provide anticipatory solutions for evolving sustainability problems before they fully manifest. These were introduced as the first suite of sustainability competencies that are problem-based, processual, and integrated in nature, involving a sequential relationship between the competencies grounded on the Cynefin problem-solving steps. This enables systematic learning of these competencies in a single instructional project, hence facilitating deep relational learning.

Furthermore, the study proposed an instructional design that situates learning of these competencies in human cognitive architecture, as explained by cognitive load theory, in order to reduce extraneous cognitive load on the limited working memory and encourage long-term memory construction in processing highly relational material. It was explained that cognitive load theory argues that the design of learning activities should understand, accommodate, and align the learner's cognitive system, the learning material, and interactions between both. Learning high interactivity material, such as sustainability competencies, could overwhelm learners by the number of information elements and their interactions, meaning that it puts high intrinsic cognitive load on the working memory which, according to cognitive load theory, should be addressed by reducing extraneous cognitive load and interference of information through spreading learning between the verbal and nonverbal sensory input channels in the working memory as identified in the dual-coding theory.

The study hypothesized there are two more mechanisms to reduce extraneous cognitive load than the dual sensory channels emphasized by the cognitive load theory. It argued that tailoring learning modalities to learning content and talent profiles of learners could also help reduce extraneous cognitive load. Reflecting on this, the study suggested and explained that each of the five sustainability competencies is best learned through a particular set of the nine human intelligences identified by the theory of multiple intelligences, and that instructors keep

shifting in tailored multimodal teaching of these competencies to support different intelligence profiles of students.

The findings of this study involve novel implications for education policy, instructional design, and research about problem-based learning and education for sustainable development. Cognitive studies about education are encouraged to test the hypothesis that tailoring learning modalities to learning content reduces extraneous cognitive load and supports long-term memory construction. More specifically, future research is encouraged to examine the hypothetical assignment of most supportive intelligences to each of the five sustainability competencies.

## References

- Amprazis, A., and P. Papadopoulou. 2025. "Key Competencies in Education for Sustainable Development: A Valuable Framework for Enhancing Plant Awareness." *Plants, People, Planet* 7, no. 4: 1195–1211.
- Aromataris, E., C. Lockwood, K. Porritt, B. Pilla, and Z. Jordan. 2024. *JBI Manual for Evidence Synthesis*. JBI. <https://jbi-global-wiki.refined.site/space/MANUAL>.
- Baddeley, A. D. 1986. *Working Memory*. Clarendon Press.
- Bas, G. 2016. "The Effect of Multiple Intelligences Theory-Based Education on Academic Achievement: A Meta-Analytic Review." *Educational Sciences: Theory and Practice* 16, no. 6: 1833–1864.
- Batsa, A. S., S. Li, and A. Khajuria. 2025. "Action Competence in Sustainable Development (ACiSD): A Systematic Review of the Contributing Factors and Learning Strategies." *International Journal of Development and Sustainability* 14, no. 1: 29–70.
- Beagon, U., K. Kövesi, B. Tabas, et al. 2023. "Preparing Engineering Students for the Challenges of the SDGs: What Competences Are Required?" *European Journal of Engineering Education* 48, no. 1: 1–23.
- Bianchi, G. 2020. *Sustainability Competences*, 1–73. Publications Office of the European Union.
- Brundiers, K., M. Barth, G. Cebrián, et al. 2021. "Key Competencies in Sustainability in Higher Education—Toward an Agreed-Upon Reference Framework." *Sustainability Science* 16, no. 1: 13–29.
- Caskey, S., and A. Williams. 2025. "Governance and Resilience: A Holistic Approach to Systems Security in Complex and Chaotic Environments." *Insight* 28, no. 3: 29–34.
- Chikezie, I. J. 2024. "Assessment of Multiple Intelligences and Effective Teaching and Learning of Igbò Language in Southeast Geo-Political Zone, Nigeria." In *Studies on Indigenous Signed and Spoken Languages in Africa*, edited by E. Asonye and M. Edward, 178–193. Cambridge Scholars Publishing.
- Cuadrado-Ballesteros, B., M. I. González-Bravo, J. Martínez-Ferrero, and E. Lahuerta-Otero. 2025. "Bridging Knowledge and Action: Sustainable Development Through Learning Landscapes in Higher Education." *Innovations in Education and Teaching International*: 1–17. <https://doi.org/10.1080/14703297.2025.2516113>.
- De Haan, G. 2006. "The BLK '21' Programme in Germany: A 'Gestaltungskompetenz'-Based Model for Education for Sustainable Development." *Environmental Education Research* 12, no. 1: 19–32.
- de Kraker, J., A. Lansu, and M. C. van Dam-Mieras. 2007. "Competences and Competence-Based Learning for Sustainable Development." In *Crossing Boundaries: Innovative Learning for Sustainable Development in Higher Education*, edited by J. de Kraker, A. Lansu, and M. C. van Dam-Mieras, 103–114. Verlag für Akademische Schriften.
- D'Silva, M. N., and A. Pande. 2025. "Mapping the Nexus Between Multiple Intelligences and Managerial Competency: A Systematic Review." *Journal of Informatics Education and Research* 5, no. 3: 1450–1466.
- Elliot, J. 2007. "From 'Human Capital' Theory to 'Capability Theory' as a Driver of Curriculum Reform: A Reflection on the Educational Implications of the Work of Amartya Sen in the Light of John Dewey's Account of Educational Values." In *Knowledge Production: Research Work in Interesting Times*, edited by B. Somekh and T. Schwandt, 142–165. Routledge.
- Elmose, S., and W. M. Roth. 2005. "Allgemeinbildung: Readiness for Living in Risk Society." *Journal of Curriculum Studies* 37, no. 1: 11–34.
- Evans, T. L. 2019. "Competencies and Pedagogies for Sustainability Education: A Roadmap for Sustainability Studies Program Development in Colleges and Universities." *Sustainability* 11, no. 19: 5526.
- Frisk, E., and K. L. Larson. 2011. "Educating for Sustainability: Competencies & Practices for Transformative Action." *Journal of Sustainability Education* 2, no. 1: 1–20.
- Gardner, H. 1983. *Frames of Mind: A Theory of Multiple Intelligences*. Basic Books.
- Gardner, H. 2008. *Multiple Intelligences: New Horizons in Theory and Practice*. Basic Books.
- Gardner, H., and T. Hatch. 1989. "Educational Implications of the Theory of Multiple Intelligences." *Educational Researcher* 18, no. 8: 4–10.
- Ghorbani, S., and S. E. Mirshah Jafari. 2025. "Fostering 21st-Century Learners' Key Competencies With an Emphasis on Curriculum Content Characteristics: A Step Toward Sustainable Development." *Journal of Applied Research in Higher Education*: 1–17. <https://doi.org/10.1108/JARHE-12-2024-0708>.
- Gouws, F. E. 2007. "Teaching and Learning Through Multiple Intelligences in the Outcomes-Based Education Classroom." *Africa Education Review* 4, no. 2: 60–74.
- Gray, K. C., and J. E. Waggoner. 2002. "Multiple Intelligences Meet Bloom's Taxonomy." *Kappa Delta Pi Record* 38, no. 4: 184–187.
- Günther, J., S. Muster, K. Kaiser, and M. Rieckmann. 2024. "A Multi-Stakeholder Perspective on the Development of Key Competencies for Sustainability in Education for Sustainable Development at School." *Environmental Education Research* 30, no. 10: 1651–1667.
- Güven, N. A., and M. A. Uyulgan. 2021. "An Active Learning Framework for Ecological Intelligence: Using Activities of Multiple Intelligences to Achieve Ecological Awareness." *Science Education International* 32, no. 4: 358–367.
- Hammer, T., and A. L. Lewis. 2023. "Which Competencies Should Be Fostered in Education for Sustainable Development at Higher Education Institutions? Findings From the Evaluation of the Study Programs at the University of Bern, Switzerland." *Discover Sustainability* 4, no. 1: 19.
- Jiang, D. 2024. *Cognitive Load Theory and Foreign Language Listening Comprehension*. Springer Nature Singapore.
- Khalid Malik, M. S., Z. Qi, M. Iqbal, S. Zamir, and B. F. Malik. 2022. "Education for Sustainable Development: Secondary School Teacher's Awareness and Perception of Integration." *Sustainable Development* 31, no. 3: 1515–1525. <https://doi.org/10.1002/sd.2463>.
- Khan, R. U., N. Sadiq, A. H. Bhatti, and M. Waqas. 2025. "Multiple Intelligences as a Framework for Students' Holistic Development: Analysis and Way Forward." *Annual Methodological Archive Research Review* 3, no. 4: 491–501.
- Klepsch, M., and T. Seufert. 2020. "Understanding Instructional Design Effects by Differentiated Measurement of Intrinsic, Extraneous, and Germane Cognitive Load." *Instructional Science* 48, no. 1: 45–77.
- Krüger, C., A. F. Pennabel, M. S. B. de Oliveira, F. H. C. B. Guimarães, and A. C. F. Caldana. 2025. "Model for Fostering Competencies for

- Sustainable Development in HEI: Human Resources as Drivers of the Process." *International Journal of Management Education* 23, no. 3: 101238.
- Lambrechts, W., I. Mulà, K. Ceulemans, I. Molderez, and V. Gaeremynck. 2013. "The Integration of Competences for Sustainable Development in Higher Education: An Analysis of Bachelor Programs in Management." *Journal of Cleaner Production* 48: 65–73.
- Lambrechts, W., and P. Van Petegem. 2016. "The Interrelations Between Competences for Sustainable Development and Research Competences." *International Journal of Sustainability in Higher Education* 17, no. 6: 776–795.
- Lans, T., V. Blok, and R. Wesselink. 2014. "Learning Apart and Together: Towards an Integrated Competence Framework for Sustainable Entrepreneurship in Higher Education." *Journal of Cleaner Production* 62: 37–47.
- Lotz-Sisitka, H., and G. Raven. 2009. "South Africa: Applied Competence as the Guiding Framework for Environmental and Sustainability Education." In *Work, Learning and Sustainable Development: Opportunities and Challenges*, edited by J. Fien, R. Maclean, and M. G. Park, 308–318. Springer.
- Lozano, R., M. Y. Merrill, K. Sammalisto, K. Ceulemans, and F. J. Lozano. 2017. "Connecting Competences and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal." *Sustainability* 9, no. 10: 1889.
- MacDonald, L., and M. Shriberg. 2016. "Sustainability Leadership Programs in Higher Education: Alumni Outcomes and Impacts." *Journal of Environmental Studies and Sciences* 6, no. 2: 360–370.
- Mayer, R. E. 2001. *Multimedia Learning*. Cambridge University Press.
- Mayer, R. E. 2022. "Cognitive Theory of Multimedia Learning." In *The Cambridge Handbook of Multimedia Learning*, edited by R. E. Mayer and L. Fiorella, 57–72. Cambridge University Press.
- Mayer, R. E. 2024. "The Past, Present, and Future of the Cognitive Theory of Multimedia Learning." *Educational Psychology Review* 36, no. 1: 8.
- McClellan, J. A., and G. J. Conti. 2008. "Identifying the Multiple Intelligences of Your Students." *Journal of Adult Education* 37, no. 1: 13–32.
- Michel, J. O., K. Brundiers, M. Barth, et al. 2023. "Sustainability Competencies in Higher Education." In *The Palgrave Encyclopedia of Urban and Regional Futures*, edited by R. C. Brears, 1710–1715. Springer International Publishing.
- Mochizuki, Y., and Z. Fadeeva. 2010. "Competences for Sustainable Development and Sustainability." *International Journal of Sustainability in Higher Education* 11, no. 4: 391–403.
- Murphy, R. 2012. "Sustainability: A Wicked Problem." *Sociologica* 6, no. 2: 1–23.
- Murtaza, R., and M. Maqbool. 2024. "Challenges in Implementing Sustainable Education Programs in Developing Nations." *Journal of Applied Linguistics and TESOL (JALT)* 7, no. 4: 389–400.
- Ngandoh, S. T., R. Adi Rahmat, and A. B. Muslim. 2025. "Trends and Issues in Cognitive Load Theory Research in Science Education (2003–2023): A Bibliometric Analysis." *AIP Conference Proceedings* 3206, no. 1: 080009. <https://doi.org/10.1063/5.0260037>.
- Nicholson-Nelson, K. 1998. *Developing Students' Multiple Intelligences*. Scholastic Professional Books.
- Paas, F., A. Renkl, and J. Sweller. 2004. "Cognitive Load Theory: Instructional Implications of the Interaction Between Information Structures and Cognitive Architecture." *Instructional Science* 32, no. 1/2: 1–8.
- Paivio, A. 1986. *Mental Representations: A Dual-Coding Approach*. Oxford University Press.
- Paivio, A. 2014a. "Empirical Case for Dual-Coding." In *Imagery, Memory and Cognition*, edited by J. C. Yuille, 307–332. Psychology Press.
- Paivio, A. 2014b. "Intelligence, Dual Coding Theory, and the Brain." *Intelligence* 47: 141–158.
- Phillips, H. 2010. "Multiple Intelligences: Theory and Application." *Perspectives in Learning* 11, no. 1: 4–11.
- Price, E., D. T. Nicholson, R. Dunk, et al. 2024. "Enabling Change Agents for Sustainable Development: A Whole-Institution Approach to Embedding the UN Sustainable Development Goals in Higher Education." *International Journal of Sustainability in Higher Education* 25, no. 7: 1333–1350.
- Ramaley, J. A. 2014. "The Changing Role of Higher Education: Learning to Deal With Wicked Problems." *Journal of Higher Education Outreach and Engagement* 18, no. 3: 7–22.
- Redman, A., and A. Wiek. 2021. "Competencies for Advancing Transformations Towards Sustainability." *Frontiers in Education* 6: 785163.
- Reed, S. K. 2006. "Cognitive Architectures for Multimedia Learning." *Educational Psychologist* 41, no. 2: 87–98.
- Rieckmann, M. 2012. "Future-Oriented Higher Education: Which Key Competencies Should Be Fostered Through University Teaching and Learning?" *Futures* 44, no. 2: 127–135.
- Roorda, N. 2010. "Sailing on the Winds of Change: The Odyssey to Sustainability of the Universities of Applied Sciences in the Netherlands." Doctoral thesis, Maastricht University. <https://doi.org/10.26481/dis.20101021nr>.
- Rychen, D. S. 2003. "Key Competencies: Meeting Important Challenges in Life." In *Key Competencies for a Successful Life and a Well-Functioning Society*, edited by D. S. Rychen and L. H. Salganik, 63–107. Hogrefe & Huber Publishers.
- Salonen, A. O., and J. Siirilä. 2019. "Transformative Pedagogies for Sustainable Development." In *Encyclopedia of Sustainability in Higher Education*, edited by W. Leal Filho, 1–7. Springer.
- Schmidt, H. G., S. M. Loyens, T. Van Gog, and F. Paas. 2007. "Problem-Based Learning Is Compatible With Human Cognitive Architecture: Commentary on Kirschner, Sweller, and Clark (2006)." *Educational Psychologist* 42, no. 2: 91–97.
- Scoones, I., M. Leach, A. Smith, S. Stagl, A. Stirling, and J. Thompson. 2007. "Dynamic Systems and the Challenge of Sustainability." STEPS Working Paper 1. [https://opendocs.ids.ac.uk/articles/report/Dynamic\\_Systems\\_and\\_the\\_Challenge\\_of\\_Sustainability/26449369?file=48097939](https://opendocs.ids.ac.uk/articles/report/Dynamic_Systems_and_the_Challenge_of_Sustainability/26449369?file=48097939).
- Shearer, C. B., and J. M. Karanian. 2017. "The Neuroscience of Intelligence: Empirical Support for the Theory of Multiple Intelligences?" *Trends in Neuroscience and Education* 6: 211–223.
- Shephard, K. 2015. *Higher Education for Sustainable Development*. Palgrave Macmillan.
- Sinakou, E., V. Donche, and P. Van Petegem. 2022. "Action-Oriented in Education for Sustainable Development: Teachers' Interests and Instructional Practices." *Journal of Cleaner Production* 370: 133469.
- Sithara, H. 2025. "Transforming Education Through Multiple Intelligences: Theory, Implementation, and Impacts." *Crossroads of Social Inquiry* 1, no. 3: 57–67.
- Sleurs, W. 2008. "Competencies for ESD (Education for Sustainable Development) Teachers: A Framework to Integrate ESD in the Curriculum of Teacher Training Institutes." *American Psychologist* 53, no. 4: 449–455.
- Snowden, D. 2002. "Complex Acts of Knowing: Paradox and Descriptive Self-Awareness." *Journal of Knowledge Management* 6, no. 2: 100–111.
- Snowden, D. 2010. "The Origins of Cynefin." [http://cognitiveedge.com/uploads/articles/The\\_Origins\\_of\\_Cynefin-Cognitive\\_Edge.pdf](http://cognitiveedge.com/uploads/articles/The_Origins_of_Cynefin-Cognitive_Edge.pdf).

- Snowden, D. 2011. "Cynefin Framework: Snowden – Own Work." [https://upload.wikimedia.org/wikipedia/commons/7/76/Cynefin\\_framework,\\_February\\_2011\\_\(2\).jpeg](https://upload.wikimedia.org/wikipedia/commons/7/76/Cynefin_framework,_February_2011_(2).jpeg).
- Snowden, D. J., and M. E. Boone. 2007. "A Leader's Framework for Decision Making." *Harvard Business Review* 85, no. 11: 1–9.
- Sorden, S. D. 2005. "A Cognitive Approach to Instructional Design for Multimedia Learning." *Informing Science* 8: 263–279.
- Spangenberg, J. H. 2014. "Sustainability and the Challenge of Complex Systems." In *Theories of Sustainable Development*, edited by J. C. Enders and M. Remig, 89–111. Routledge.
- Surbakti, R., S. E. Umboh, M. Pong, and S. Dara. 2024. "Cognitive Load Theory: Implications for Instructional Design in Digital Classrooms." *International Journal of Educational Narratives* 2, no. 6: 483–493.
- Svanström, M., F. J. Lozano-García, and D. Rowe. 2008. "Learning Outcomes for Sustainable Development in Higher Education." *International Journal of Sustainability in Higher Education* 9, no. 3: 339–351.
- Sweller, J. 2003. "Evolution of Human Cognitive Architecture." *Psychology of Learning and Motivation* 43: 216–266.
- Sweller, J. 2023. "The Development of Cognitive Load Theory: Replication Crises and Incorporation of Other Theories Can Lead to Theory Expansion." *Educational Psychology Review* 35: 95.
- Sweller, J. 2024. "Cognitive Load Theory and Individual Differences." *Learning and Individual Differences* 110: 102423.
- Sweller, J., J. J. Van Merriënboer, and F. G. Paas. 1998. "Cognitive Architecture and Instructional Design." *Educational Psychology Review* 10, no. 3: 251–296.
- Sweller, J., J. J. Van Merriënboer, and F. Paas. 2019. "Cognitive Architecture and Instructional Design: 20 Years Later." *Educational Psychology Review* 31, no. 2: 261–292.
- Tabassum, R., S. Saleem, and S. Taj. 2024. "Relationship Between Multiple Intelligences and Digital Literacy Skills Among University Students." *Journal of Social Research Development* 5, no. 2: 70–83.
- Tilbury, D., and D. Wortman. 2004. *Engaging People in Sustainability*. IUCN. [https://education21.ch/sites/default/files/uploads/pdf-en/2004\\_IUCN\\_Engaging-People-in-Sustainability.pdf](https://education21.ch/sites/default/files/uploads/pdf-en/2004_IUCN_Engaging-People-in-Sustainability.pdf).
- Torsdottir, A. E., D. Olsson, and A. T. Sinnes. 2024. "Developing Action Competence for Sustainability – Do School Experiences in Influencing Society Matter?" *Global Environmental Change* 86: 102840.
- Tricco, A. C., E. Lillie, W. Zarin, et al. 2018. "PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation." *Annals of Internal Medicine* 169, no. 7: 467–473.
- UNESCO. 2017. "Education for Sustainable Development Goals: Learning Objectives." <https://unesdoc.unesco.org/ark:/48223/pf0000247444/PDF/247444eng.pdf.multi>.
- United Nations. 2015. "Transforming Our World: The 2030 Agenda for Sustainable Development." <https://docs.un.org/en/A/RES/70/1>.
- United Nations. 2025. "The Sustainable Development Goals Report 2025." <https://unstats.un.org/sdgs/report/2025/The-Sustainable-Development-Goals-Report-2025.pdf>.
- Venn, R., P. Perez, and V. Vandenbussche. 2022. "Competencies of Sustainability Professionals: An Empirical Study on Key Competencies for Sustainability." *Sustainability* 14, no. 9: 4916.
- Versace, R., E. Labeye, G. Badard, and M. Rose. 2009. "The Contents of Long-Term Memory and the Emergence of Knowledge." *European Journal of Cognitive Psychology* 21, no. 4: 522–560.
- Wagner, U., L. Handke, and H. Walter. 2015. "The Relationship Between Trait Empathy and Memory Formation for Social vs. Non-Social Information." *BMC Psychology* 3, no. 1: 2.
- Wiek, A., M. J. Bernstein, R. W. Foley, et al. 2016. "Operationalizing Competencies in Higher Education for Sustainable Development." In *Routledge Handbook of Higher Education for Sustainable Development*, edited by M. Barth, G. Michelsen, M. Rieckmann, and I. Thomas, 241–260. Routledge.
- Wiek, A., L. Withycombe, and C. L. Redman. 2011. "Key Competencies in Sustainability: A Reference Framework for Academic Program Development." *Sustainability Science* 6, no. 2: 203–218.
- Willard, M., C. Wiedmeyer, R. W. Flint, et al. 2010. "The Sustainability Professional: 2010 Competency Survey Report." *Environmental Quality Management* 20, no. 1: 49–83.
- Wooten, J. O., and J. A. Cuevas. 2024. "The Effects of Dual Coding Theory on Social Studies Vocabulary and Comprehension in Elementary Education." *International Journal on Social and Education Sciences* 6, no. 4: 673–691.
- Ziafati Bafarasat, A. 2021. "Meta-Synthesis of COVID-19 Lessons: Charting Sustainable Management of Future Pandemics." *International Journal of Urban Sciences* 25, no. 3: 299–322.
- Ziafati Bafarasat, A., M. Baker, A. Cheshmehzangi, et al. 2025. "Planning Competencies and Transformative Pedagogy for Sustainable Development." *Progress in Planning* 200: 100996. <https://doi.org/10.1016/j.progress.2025.100996>.
- Ziafati Bafarasat, A., E. Oliveira, and G. M. Robinson. 2023. "Re-Introducing Statutory Regional Spatial Planning Strategies in England: Reflections Through the Lenses of Policy Integration." *Planning Practice & Research* 38, no. 1: 6–25.
- Ziafati Bafarasat, A., and L. Pugalís. 2020. "In Search of Cohesive Metropolitan Governance: Enticements and Obligations." *European Planning Studies* 28, no. 8: 1474–1492.
- Ziafati Bafarasat, A., and A. Sharifi. 2024. "How to Achieve a Healthy City: A Scoping Review With Ten City Examples." *Journal of Urban Health* 101, no. 1: 120–140.
- Zou, L., Z. Zhang, M. Mavilidi, et al. 2025. "The Synergy of Embodied Cognition and Cognitive Load Theory for Optimized Learning." *Nature Human Behaviour* 9: 877–885.