
# Research Paper

Recommended citation: Marttila, M., Äijälä, M., Tedeschi, M., Shaw, M., & Levänen, J. (2025). Developing Sustainability Competences Through a Negotiation Simulation Role-Playing Game. In Kangaslampi, R., Langie, G., Järvinen, H.-M., & Nagy, B. (Eds.), SEFI 53rd Annual Conference. European Society for Engineering Education (SEFI), Tampere, Finland. DOI: 10.5281/zenodo.17631440.

# DEVELOPING SUSTAINABILITY COMPETENCES THROUGH A NEGOTIATION SIMULATION ROLE-PLAYING GAME

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***Conference Key Areas**: 7. Sustainability and society in engineering; 10. Engineering skills, professional skills, and transversal skills*
***Keywords**: Sustainability, Competences, Simulation, Role-playing, Active learning*

## ABSTRACT

This study investigated the effectiveness of a negotiation simulation role-playing game as a pedagogical tool for developing the sustainability competences of university engineering students. In an active learning environment, students engaged in a role-playing exercise, assuming the roles of diverse stakeholders debating the future of a coal-burning plant in the fictional city of Pinehill.

The research examined how an experiential, yet safe real-world simulation influenced the development of key sustainability competences, such as systems thinking, strategic collaboration, and future-oriented analytical thinking, which are essential skills for navigating complex sustainability transitions. With perspectives of different actors 'embodied' during the simulation, the game also enhanced the ability to consider diverse viewpoints in decision-making.

Data was collected through group reflection reports and surveys, utilizing both qualitative and quantitative methods to assess students' learning experiences and competence development. It was observed that participation in the simulations empowered students with deepened competences in sustainability, especially regarding interpersonal skills.

This research contributes to engineering education by presenting that simulation role-playing games can narrow the gap between theoretical knowledge and real-world application while developing key sustainability competences that traditional classroom methods are unlikely to deliver.

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# 1 INTRODUCTION

There is a critical need to equip future professionals with sustainability competences and enable them to integrate environmental, social, and economic dimensions into the transformative changes and transitions essential to drive societies towards sustainability (Loorbach et al., 2017; Köhler et al., 2019). Since the early 1990s, Education for Sustainable Development (ESD) has been recognized as a key response to global sustainability challenges (Boeve-de Pauw et al., 2015). However, traditional teaching methods often fall short in providing students with the necessary skills for real-world decision-making, for example regarding multi-stakeholder negotiations and changes in complex systems.

To address this gap, participatory modelling and serious games, such as role-playing and simulations (Fletcher et al., 2008; Abrami et al., 2021; Peña Miguel et al., 2020), have been increasingly studied as pedagogical tools in sustainability education (Rumore et al., 2016; Duchatelet et al., 2019). Simulation games, for instance, have been found to be among the most effective means to facilitate learning complex skills across domains (Chernikova et al., 2020). Earlier research has proposed that the key competences in sustainability are systems thinking, anticipatory skills, normative reflection, strategic decision-making, and interpersonal skills (Wiek et al., 2011). Development of these competences should be targeted in the classroom as a backbone for teaching future sustainability professionals (Brundiers et al., 2010; Brundiers & Wiek, 2017).

By integrating two of the main self-perception-based methods of assessing sustainability competences, reflective writing and scaled self-assessment (Redman et al., 2021), this study uses a structured negotiation role-playing game as a case study to explore three key questions:

1) What types of sustainability competences do engineering students develop through participation in such simulations?

2) How effectively does the simulation foster these competences?

3) How do different stakeholder roles influence students' learning outcomes?

With sustainability challenges becoming increasingly pressing, equipping students with the competences needed for systemic transformation is essential in fostering the next generation of sustainability professionals (Brundiers et al., 2021). The findings of this research contribute to sustainability pedagogy by recommending integrating similar innovative learning approaches into engineering curricula.

# 2 METHODOLOGY

## 2.1 Participants and context

The participants were Master's level university students mainly from different engineering disciplines at LUT University, enrolled in the "Sustainability in a Socio-Technological Context" course during the academic year 2024-2025. As part of the course, students participated in a futures negotiation role-playing game and wrote a group reflection on the game afterwards.

## 2.2 The negotiation simulation

The negotiation simulation game applied in this study was a structured role-playing exercise, similar to presented in Fletcher et al. (2008). The game, entitled *Pinehill Futures,* was designed to engage students in a complex sustainability decision-making scenario, and to assume the roles of diverse stakeholders debating the future of a coal-burning heating plant in the fictional city of Pinehill. This experiential learning activity was designed to mimic complex real-world sustainability transitions, facilitating emotional engagement with diverse stakeholder perspectives and the challenges that come with attempting to align them towards a sustainable solution.

The different stakeholders represented in the simulation include:

| **Stakeholder Group** | **Role Description** |
|---|---|
| Pinehill City Council | Facilitates the negotiation process; ensures fair discussion; responsible for municipal policy and long-term sustainability planning. |
| Pinehill Local Energy Company | Defends the continued operation of the coal plant; emphasizes energy security and local economic stability. |
| Geothermal District Heating Company | Proposes a transition to renewable geothermal energy; promotes clean and sustainable energy solutions. |
| Forest Owner Association | Advocates the use of locally sourced biomass as an alternative energy source; concerned for management of forest for economic benefit. |
| Environmental NGO | Opposes coal energy; pushes for sustainable and low-emission alternatives with caution regarding other environmental impacts. |
| Citizen Group of Pinehill | Represents residents' concerns about employment, environment quality, and the community's economic future. |

The simulation had the following four-phase structure:

| **Phase** | **Description** |
|---|---|
| Preparation | Students familiarize with their assigned stakeholder position, reviewing relevant background information, sustainability impacts, and argumentation. |
| Negotiation | Students impersonate the different stakeholders engaging in structured discussions, proposing solutions, and negotiating compromises to address various views on sustainability concerns. |
| Decision-making | The participants attempt to reach a consensus and manage the sustainability trade-offs regarding the future of the coal-burning plant. |
| Reflection | Students analyze the negotiation process, evaluating the challenges of stakeholder collaboration and the implications of their decisions. |

## 2.3 Data Collection

### Group reflection reports

After completing the negotiation simulation game, a total of 14 groups of students (n=94) submitted a reflection report describing their learning and insights gained from the role-playing experience. The study was conducted following ethical guidelines for educational research; participation was voluntary, and students' responses were anonymized to protect their privacy. Students were asked to evaluate the implications of their decisions made during the negotiation. This allowed students to articulate how the simulation shaped their understanding of sustainability challenges, stakeholder dynamics, and the complexity of socio-technical systems.

## Surveys

Three structured surveys were conducted at different stages of the exercise to capture students' self-assessed competence development:

| Survey stage | Description |
|---|---|
| Pre-negotiation survey (n=60) | Completed before the negotiation simulation game to establish baseline level on students' perceived sustainability competences. |
| Post-negotiation survey (n=29) | Completed immediately after the simulation to assess development in competence perceptions resulting from the negotiation simulation. |
| Post-reflection survey (n=20) | Completed after students submitted their group reflection reports to track further change in competences following reflective analysis. |

Each survey included the following instruction: "*Please assess your knowledge and skills regarding the following sustainability competences (1 = I have no knowledge; 5 = I possess extensive competence).*" This was applied to a series of competence-related concepts derived from the framework developed by Wiek et al. (2011), which defines five key sustainability competences: systems thinking, anticipatory, normative, strategic, and interpersonal.

The use of the concept-level assessment distinguished the key competences into 30 more detailed variables, capturing specific knowledge areas, skills, and abilities within each main category. This detailed structure allowed for a more nuanced assessment and tracking of development across different aspects of each competence area.

## 2.4 Data analysis

The study employed a mixed-methods approach combining qualitative analysis of group reflections and quantitative analysis of a three-phase self-assessment survey, Figure 1. Both data sources were structured using Wiek et al. (2011) framework to examine and compare competence development across key competence categories, stages of the exercise, and stakeholder roles.

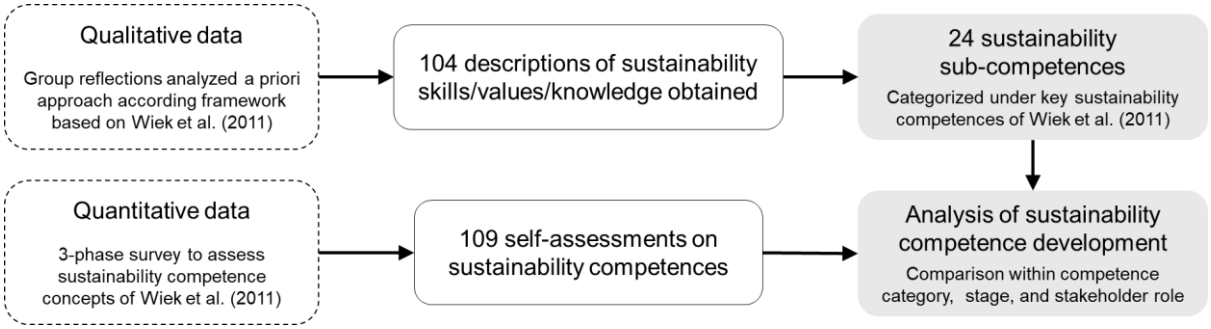


*Fig. 1. Research outline for analyzing sustainability competence development.*

### Qualitative analysis (group reflections):

While the analysis was grounded in the Wiek et al. (2011) framework, the process remained open to the identification of new or hybrid key sustainability competence categories that would emerge from the data. The analysis aimed to recognize competences outside the already existing framework or the intersection of multiple established competences.

An a-priori coding approach guided the qualitative analysis of the reflection reports. The process involved the following steps:

| Step | Description |
|---|---|
| Defining competences | Sustainability competences were defined based on the framework by Wiek et al. (2011), which served as the foundation for the analysis structure. |
| Data review | Reflection reports were systematically reviewed to identify instances where students demonstrated or discussed competences related to sustainability. |
| Classification | Identified quotes were reflected against the five key sustainability competences from Wiek et al. (2011): systems thinking, anticipatory, normative, strategic, and interpersonal competences. |
| Thematic analysis | A thematic analysis was conducted to further group the emergent themes beyond the predefined competence categories, capturing the more detailed 'sub-competences' to support the already established key competences. |

**Quantitative analysis (surveys):**

A comparative statistical analysis was conducted on survey data to measure changes in students' self-perceived sustainability competences across the three time points. Descriptive statistics were used to evaluate shifts in competence ratings and to determine statistically significant changes. Additionally, the analysis aimed to identify which specific sustainability competences students felt had developed the most throughout the negotiation simulation game. By utilizing three data collection points, the study allowed examining when development of competences occurred, providing insights into the impact of different phases of the learning process.

## 3 RESULTS

### 3.1 Identified competences

Analysis of student group reflection reports shows how different sustainability competences were emphasized in students' own articulation of their learning from the negotiation simulation. The distribution of descriptions incompetences categories, represented in Figure 2, shows the frequency of each competence as experienced by the students. For example, the following student reflection: *"We learned that negotiations may sometimes take surprising turns in the middle of the conversation and the direction of the conversation cannot always be predicted,"*

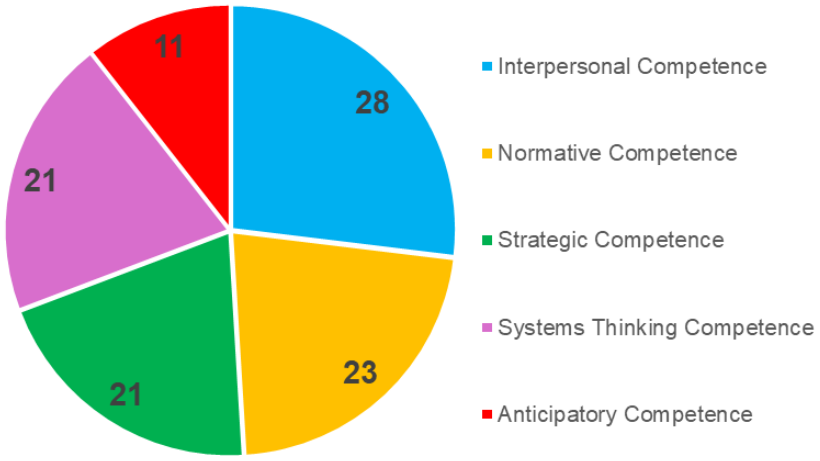


*Fig. 2. Categorization of identified competence descriptions to key competences.*

was categorized under the ‘Anticipatory Competence’, as it reflects the ability to remain flexible and maintain composure when plans are disrupted or unexpected developments occur during sustainability processes. On the other hand, the statement also demonstrates an awareness of the importance of responsiveness and openness to change during complex discussions, referring to qualities relevant to ‘Interpersonal Competence’.

The dominance of interpersonal competence in reflections indicates that students were actually invested into the exercise and dealt with real negotiation dynamics such as trust, power, and conflict, rather than superficial discussion. Frequent mentions of normative competence reflect deeper moral reasoning as students engaged with value conflicts beyond role-based arguments. Strategic and systems thinking competences were equally emphasized, indicating students' growing ability to negotiate effectively, take advantage of leverage points, and act with systemic awareness.

The 104 identified competence descriptions were grouped into 24 distinct sustainability sub-competences (Appendix I) by grouping those with shared meaning. For instance, under ‘Systems Thinking Competence’, sub-competences such as ‘*Emphasizing complexity versus linearity*’ and ‘*Understanding socio-ecological systems*’ emerged to catch the broader definition of the main category in more detail. Similarly, the interpersonal domain was enriched with sub-competences representing practical skills such as active listening, empathy, and self-awareness.

### 3.2 Self-reported development

Figure 3 illustrates the development of students' self-assessed sustainability competences across three measurement points: before the negotiation simulation (pre-negotiation), immediately after the simulation (post-negotiation), and following the submission of group reflection reports (post-reflection).

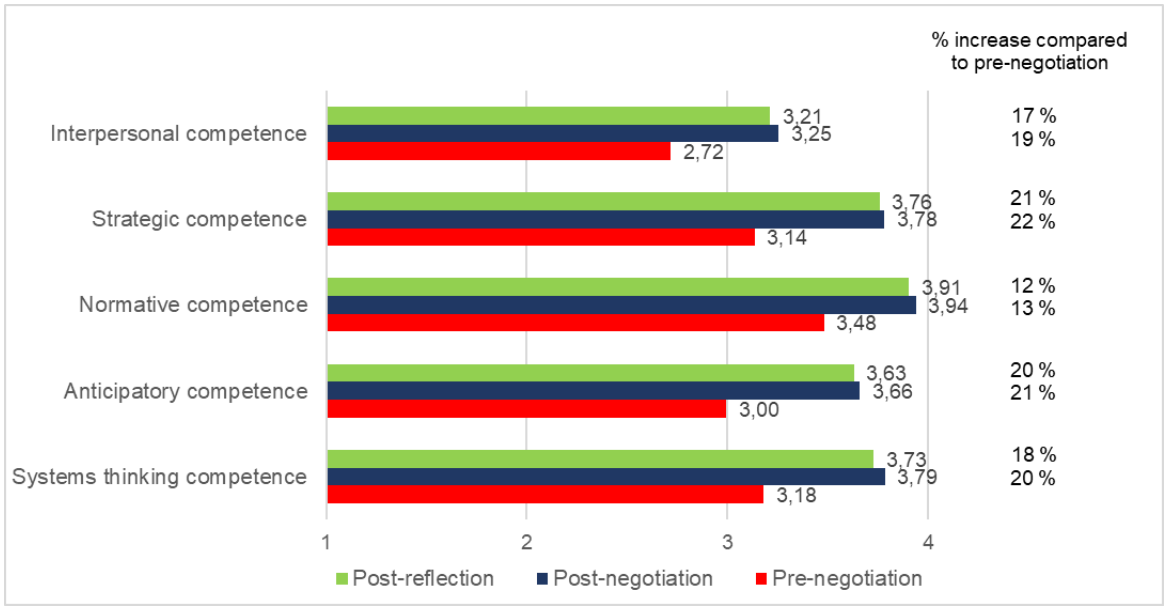


*Fig. 3. Self-assessed development of students' sustainability competences.*

Although, significant competence development was observed post-negotiation, scores slightly declined in post-reflection responses. This could simply be due to different

cohort of respondents but could also suggests that reflections encouraged more critical self-assessment, with students reassessing their competences after analyzing their performance and group dynamics more deeply.

The strongest developments were observed in strategic and anticipatory competences, reflecting the simulation's emphasis on future-oriented decision-making. Strategic competence improved most, likely due to the need for goal setting, argument preparation, and negotiation strategies. Students also engaged with future scenarios and considered long-term consequences of different transition pathways advancing the anticipatory competences. Systems thinking competence grew through working with interdependencies across ecological, social, and economic sustainability dimensions. Role-play also forced students to account for system feedbacks, trade-offs, and unintended outcomes. Surprisingly, normative competences increased modestly compared to others. However, its baseline assessment was already highest indicating potentially less room for improvement.

### 3.3 Impact of stakeholder roles

Figure 4 presents how different stakeholder roles in the negotiation simulation game contributed to the development of specific sustainability competences, based on coded content from group reflection reports. Interpersonal competence appeared prominently across all roles, especially in the City Council, Local Energy Company, and Forest Owners' Association. These groups might have required coordination with diverging interests in the negotiation. Especially, the City Council's central position in the negotiation made it responsible for stakeholder management, while NGO and geothermal roles needed persuasive communication from the outside in.

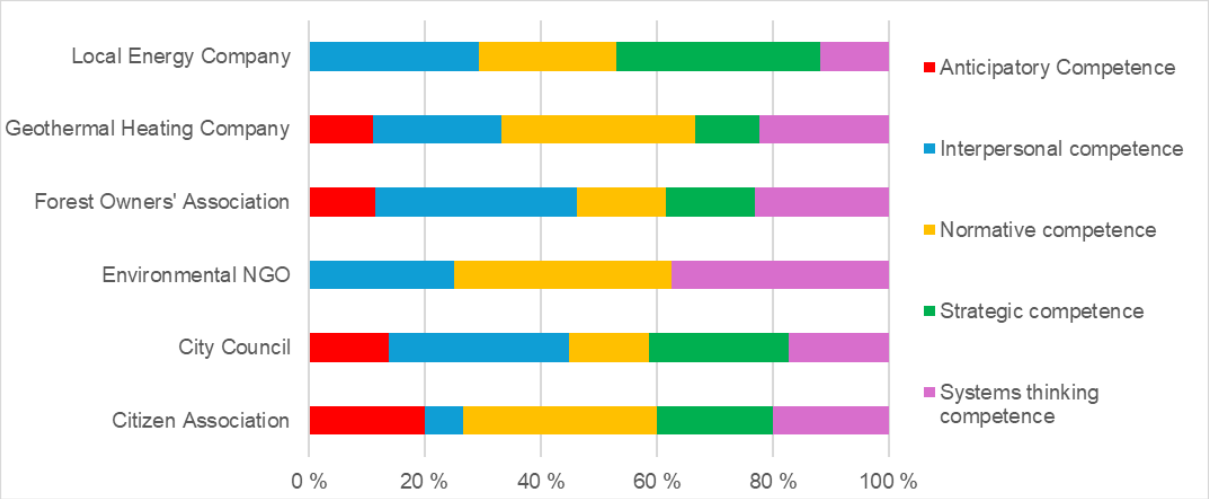


*Fig. 4. Self-assessed development of students' sustainability competences.*

Normative competence was strongly expressed in the Citizen Association, Geothermal Heating Company, and Environmental NGO. These roles invited direct engagement with ethical trade-offs and sustainability principles. Students reflected on fairness, responsibility, and long-term societal goals in their arguments to justify their positions. Strategic competence stood out in the Local Energy Company and City Council roles. These groups pushed for concrete outcomes under pressure, requiring students to think tactically, collaborate, and create strategies in real time.

Systems thinking competence was particularly evident in the Environmental NGO groups. This role involved navigating ecological, technical, and systemic interdependencies. Anticipatory competence remained marginal across roles. Its limited articulation, even in future-oriented groups such as Geothermal Company or City Council, indicates that long-term foresight was insufficiently integrated in the role design, and could be possibly improved with explicit tools for futures thinking.

## 4 DISCUSSION AND CONCLUSIONS

The findings confirm that this role-playing exercise effectively supports the development of sustainability competences, particularly those linked to negotiation, complex systems, and strategic planning. These reflect exactly the kind of competences traditional classroom pedagogies might miss, especially as the normative competences were self-assessed strongest before negotiations. Group reflections showed that students were, however, especially aware of interpersonal competence development, which is essential for stakeholder collaboration.

The simulation's role structure enabled diverse learning outcomes. Some roles emphasized collaboration and systemic aspects, while others focused on values or strategic reasoning. The distribution of competences across roles highlights how embodying different stakeholder perspectives shapes learning in simulation-game based education. What students practiced and reflected on was closely tied to the specific demands of their assigned roles.

The sub-competences recognized offer a valuable extension to the Wiek et al. (2011) framework, adding depth and clarity to already widely adopted key competence areas. By naming and clustering these sub-competences, the study connects broader competence domains with more tangible learning outcomes, strengthening the analytical utility of the framework. This complementary layer details the concrete skills and understanding related to each key competence.

The authors encountered several cases during the data analysis where individual statements in the reflections could have been interpreted as evidence of growth in multiple competence areas. This overlap highlights an important insight into competences: they are often interdependent and must work together to function effectively. This further emphasizes that sustainability competences are not clear-cut and should be co-evolved together through practical application. The fuzzy boundaries between competences that was clarified with the sub-categorization developed in this study, could be further supported with the integration of the emerging competences introduced by Redman & Wiek (2021).

A key limitation of the study is its reliance on self-assessment surveys, which may be subject to bias in how students judge their own competence levels. The short duration and relatively large group sizes in the simulation may have also limited the depth of competence development observed. Another limitation is the small number of post-survey responses, which weakens the reliability of tracking competence development over time. Although supported by qualitative reflections, inclusion of formal student appraisals could serve as additional evaluation method in future studies to confirm that self-reported development reflects actual competence improvement from the perspective of teaching staff.

## ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the Climate University network and the dedicated teachers who developed the Pinehill Futures game. Authors also acknowledge support of AI in the language refinement of the article.

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## Appendix I

Identified sub-competences categorized under key sustainability competences defined by (Wiek et al., 2011):

| Key sustainability competence (Wiek et al., 2011) | Identified sub-competence | Description |
|---|---|---|
| Anticipatory Competence | Adaptability and resilience in dynamic contexts | The ability to stay flexible and maintain composure in the occurrence of unexpected developments or disrupted plans. |
| | Planning under uncertainty and complexity | Recognizing the limits of predictability and preparing for multiple outcomes or scenarios in sustainability transitions. |
| | Balancing time horizons in decision-making | Weighing short-term and long-term sustainability goals and making informed decisions across different temporal scales. |
| | Anticipating risks and managing trade-offs | Identifying and analyzing potential risks, stakeholder concerns, and trade-offs in long-term planning. |
| Interpersonal Competence | Perspective-taking and empathy | Ability to understand, appreciate, and consider diverse stakeholder viewpoints and emotions. |
| | Active listening and communication | Skills in listening, expressing, and mediating effectively in multi-stakeholder settings. |
| | Collaboration and stakeholder engagement | Identifying diverse actors for teamwork, cooperation, and inclusive dialogue. |
| | Negotiation and conflict resolution | Navigating conflicts, compromises, and stakeholder dynamics to achieve mutually acceptable outcomes. |
| | Self-awareness and reflexivity | Recognizing one's own biases, strengths, and emotional responses in interactions. |
| Normative Competence | Understanding multi-dimensional sustainability | Recognizing the interconnected nature of environmental, social, and economic aspects in sustainability decision-making. |
| | Balancing sustainability priorities and trade-offs | Ability to evaluate and reconcile value-based tensions between economic, social, and environmental dimensions. |
| | Recognizing the complexity of wicked problems | Understanding that sustainability solutions often involve uncertain outcomes, conflicting stakeholder values, and no clear optimization. |
| | Integrating interdisciplinary perspectives | Recognizing the need for collaboration across disciplines and sectors to address complex sustainability challenges. |
| | Promoting inclusive sustainability goals | Being aware of justice-oriented, equitable sustainability planning that includes all stakeholders and dimensions. |
| | Applying sustainability in practice | Ability to translate sustainability theories and concepts to be applied in real-world contexts. |
| Strategic Competence | Using leverage points to drive transformations | Understanding and applying systemic leverage points, including timing, shared goals, and values. |
| | Information and evidence-based influence | Using information, data, and communication techniques to argue for sustainability decisions. |
| | Planning and coordination of decision-making | Applying planning, facilitation, and management skills to organize effective sustainability decision-making. |
| | Integrating diverse inputs in decision-making | Incorporating multiple viewpoints and implications in sustainability strategies. |
| | Understanding dynamics and emotions in strategy | Balancing logic and emotion, momentum, and engagement techniques to shape decision-making. |
| Systems Thinking Competence | Understanding socio-ecological systems | Recognizing how various socio-ecological elements are interconnected and influence each other. |
| | Emphasizing complexity versus linearity | Realizing that sustainability transitions involve non-linear dynamics, complexity, and multiple influencing factors. |
| | Recognizing systemic interconnections | Understanding how social, institutional, and technological systems interact and evolve together. |
| | Applying systemic models | Using systems thinking perspectives and tools to understand sustainability transitions. |