



Adaptive capacity as an educational goal to advance policy for integrating DRR into quality education for sustainable development

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ABSTRACT

This paper explores how the linkages between *quality education*, *education for sustainable development* (ESD), and *disaster risk reduction* (DRR) *education* may be strengthened and functionalised through the application of “adaptive capacity” as a common learning objective. Adaptive capacity is recognised as an important element in building social resilience and thus supporting disaster risk reduction. Five pedagogical aspects of learning for adaptive capacity are introduced as a means to strengthen pedagogical design and enhance a “phronetic approach” to sustainability learning. These pedagogical aspects are then examined from a practical standpoint through the review of four secondary DRR education cases. Learning for adaptive capacity supports pedagogical design, strengthens learning processes for competency development, and may be aligned with the main goals for achieving quality education for sustainable development – applying a well-developed curriculum, improving the quality of teaching methods, establishing a safe and effective learning environment, and inspiring cooperative and transformative learning.

1. Introduction

The 193 member states of the United Nations General Assembly, on the 25th September 2015, agreed on a new global agenda for sustainable development. The scale and ambition of this agenda are captured in the 17 Sustainable Development Goals (SDGs). This global agenda is detailed in the document *Transforming our World: the 2030 Agenda for Sustainable Development* [1] with the aim to achieve these goals by 2030. “We are determined to take the bold and transformative steps which are urgently needed to shift the world on to a sustainable and resilient path” [1]. The 2030 Agenda and the SDGs reflect a holistic perspective towards sustainable development that incorporates people, planet, prosperity, peace and partnerships into their overall framework.

This is effectively an international agreement to dramatically re-structure our societies and re-organise our patterns of development over a very short period-of-time and to do so while facing unprecedented changes in the climate and ecosystems around us. In order to reach the ambition of the sustainable development agenda, we need to develop new perspectives and search for solutions that balance social, economic and environmental dimensions and strengthen system interlinkages. Human society will work to find a path towards sustainable

development, while at the same time responding to a changing climate, extreme weather events, and increasing pressure on natural resources and ecosystems. How can we best prepare for change, and what role will education play in this?

This, in part, relies on the importance of education for sustainable development (ESD) and its ability to link learning to the contexts and challenges of everyday living. Education for sustainable development aims to empower people with values, skills and knowledge, which will help them become active agents of change in their own lives and in their wider society. “ESD pedagogies do more than facilitate learning of knowledge—they promote learning of skills, perspectives and values that sustainable societies require” [2]. Additionally, this depends on education for disaster risk reduction (DRR) that strengthens the capacities of individuals and communities to act with foresight to build resilience and to react to extreme events strategically and rationally to avoid disastrous consequences. An important challenge for education in addressing both sustainable development and disaster risk reduction is the empowerment of people to collectively transform their realities to envision and create more resilient and sustainable futures.

Education for sustainable development has a primary focus on enabling learners with the capacities and competencies to relate learned

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knowledge, skills and values towards addressing and overcoming real world challenges. ESD is strongly focused on educational practice, or the E in ESD; it is not just about including SD knowledge within the contents of the curriculum. With a leaning towards educational reform/improvement and enabling the conditions for transformative learning, ESD has recently been recognised as a model that directly strengthens the implementation of quality education [2–4]. A key challenge of quality ESD is thus ensuring the relevance of education and the applicability of knowledge and competencies for addressing sustainability challenges. This focusses on developing lifelong learning competencies needed to address sustainability across diverse contexts [5,6].

Education for sustainable development is oriented towards whole system perspectives, and it aims to achieve learning for change. In practice, this means a focus on cross-curricular and interdisciplinary approaches to teaching and a greater effort to link classroom learning to real-world application. ESD promotes a view of quality education that is concerned not just with measurable learning outcomes and national standards, but rather with encouraging lifelong learning and developing the skills, values and competencies of learners to become agents of change. ESD uses participatory, active learning methods that promote experiential education, collective problem solving and democratic dialogue. Several authors place strong emphasis on the pedagogical nature of ESD and emphasise that the learning processes play a more significant role than the sustainability contents [6–9].

DRR perspectives in education have focussed significantly on school safety, and while there has been an effort to strengthen learning for DRR, this has not had significant linkage to the examination of the overall quality of education. However, it is possible to recognise strong similarities between the desired skill and competency development in ESD and DRR. “Drawing upon different stages of the commonly described disaster management cycle, DRR education calls for systemic and systematic attention to the hazard combined with preparedness and resilience building so as to avoid the hazard morphing into disaster” [10]. As much of the training on DRR occurs in non-formal settings and for local communities, many DRR learning activities have not been developed to connect to a more comprehensive educational model. Following the International Decade for Natural Disaster Reduction during the 1990s, DRR education has increasingly been characterised by experience-based and action-oriented learning, as well as with efforts to bridge formal and non-formal education and with the school serving as a central learning hub [11]. The “comprehensive school safety framework” aligns three pillars: safe learning facilities (i.e., the physical structure of schools), school disaster management (i.e., assessment, planning and management), and risk reduction and resilience education (i.e., teaching and learning approaches that include ESD) [12]. Where DRR education is established in formal settings or with a level of continuity and progressive development, then a more thorough review may be conducted on the links between ESD and DRR learner development.

DRR education is gaining greater placement within school curriculums in a structured manner, and in this form it is strengthening the application of knowledge, skills and values learned in the classroom to tackle real-life challenges. It can lead to enhanced civic participation and engagement in decision-making processes, especially by young learners [13]. Apronti et al. highlight though that equally important to the contents of DRR education are the teaching, learning and evaluation techniques that are used [14]. Muttarak and Pothisiri find that higher levels of education can lead to better translation of previous experiences into future preparedness and increase the impacts of additional DRR training activities [15]. Benadusi stresses that awareness raising alone is not effective in DRR, and argues that an approach that involves local communities in identifying the threats present in their specific context and finding appropriate solutions to mitigate these threats is essential in building capacity for DRR [16]. While Mercer et al. demonstrate how participation in identifying and examining such threats can be an important way to value indigenous knowledge and intangible cultural heritage, but at the same time also promote critical examination of

attitudes and beliefs in a manner that may lead to behaviour change [17]. These findings provide some indication of the overall benefit education provides through developing cognitive ability, learning skills, abstract thinking and risk assessment capacities.

In this paper, we explore how adaptive capacity may be applied as a unifying learning objective to align efforts towards *quality education*, *education for sustainable development* (ESD), and *disaster risk reduction* (DRR) education. Adaptive capacity has previously been discussed in relation to climate change adaptation [18–21], and it shares similarities with discussions about resilience raised in the DRR literature [22–25]. While resilience is often used more in reference to whole systems and a system’s ability to recover from and return to normal functionality following a shock, adaptive capacity is regularly applied in reference to human ability at individual, collective and institutional levels. Alexander explains how resilience in ecological systems refers to maintaining the system’s integrity, but in social systems it is more about being better able to deal with extreme situations [26]. Folke et al. actually define adaptive capacity as “The capacity of actors in a system to influence resilience” [27]. Recent studies have specifically aimed to measure the benefit education has for climate change adaptation [28,29], and Lutz, Muttarak, and Striessnig highlight that education has one of the most significant correlations with vulnerability reduction and adaptive capacity enhancement due in large part to education’s links to strengthened cognitive capacity [30].

Adaptive capacity will be discussed in this paper as a dynamic set of learned skills and competencies that apply to both individual and collective learning. The aim of adaptive capacity is to strengthen the ability of learners to collaborate in processes of critical reflection for examining current systems; assessing their strengths and weaknesses, as well as identifying potential shocks and hazards; and to act with strategic foresight to increase system resilience and to transform socio-ecological systems towards sustainable pathways. Transformative learning for sustainable development and resilience thinking are key components of adaptive capacity. “Resilience thinking is about understanding and engaging with a changing world. By understanding how and why the system as a whole is changing, we are better placed to build a capacity to work with change, as opposed to being a victim of it” [31].

This paper is based on a theoretical (non-systematic) literature review, and it draws additional insight from a small number of secondary case studies. A theoretical literature review was chosen due to the interdisciplinary nature of the topics explored as a means to identify and examine the relationships between the existing theories around capacity and competency development in education, especially as related to sustainable development and DRR, as well as the broader use of adaptive capacity within environmental and sustainability fields. It was a non-systematic literature review, and the aim was not to produce a meta-analysis or synthesis of the literature but rather to identify a point of common alignment (and hopefully synergy) for quality education, ESD and DRR education.

The remainder of this paper explores the concept of learning for adaptive capacity. In section 2, the dual need for competency development and proficient application of competencies across diverse contexts is discussed as a key challenge in learning for adaptive capacity. In section 3, the pedagogical aspects of ESD and DRR education are examined, and five pedagogical aspects of learning for adaptive capacity are introduced to support effective pedagogical design. In section 4, four DRR education case studies are reviewed from a perspective of learning for adaptive capacity. Section 5 concludes with a discussion regarding how learning for adaptive capacity may be aligned with the main objects for achieving quality education – applying a well-developed curriculum, improving the quality of teaching methods, establishing a safe and effective learning environment, and inspiring cooperative and transformative learning.

2. Learning for change and adaptive capacity

The purpose of this paper is to align the current perspectives towards quality education, ESD and DRR education by better understanding how learning for adaptive capacity is achieved, both in relation to competency development and applied practice. When working to define adaptive capacity in a learning context, it may be possible to identify specific characteristics, skills and even values that strengthen an individual's overall adaptive capacity. If so, then it may also be possible to target these aspects in pedagogical design and through specific lessons and instruction, as a first step in developing one's adaptive capacity and its proficient application. The discussion on learning for adaptive capacity presented in this paper is not arguing to introduce a new 'grand challenge' or theory into the practice of ESD and DRR education. In fact, there is strong acknowledgement that existing ESD and DRR education practices already achieve varying levels of learning for adaptive capacity.

Competency development and skill learning play a foundational role in building adaptive capacity, but it also depends on an individual's ability to apply their competencies and skills across a diversity of situations in an adaptive manner. Grothmann and Patt highlight the difference between the objective (real) ability and the subjective (perceived) ability an individual holds when it comes to adaptive capacity [20]. People's decisions will often be more influenced by their subjective ability, both what they perceive as the potential risk and their own perceived adaptive capacity. From a learning perspective, this raises the challenge or need to try to align one's subjective and objective ability as closely as possible so that the decisions made based on one's own perceived adaptive capacity is not under or over-estimating what objectively could be achieved. This is a key challenge for transformative learning both at individual and collective/social levels [32,33].

Learning for adaptive capacity cannot be achieved solely through a process of instruction. Instruction-based teaching may raise awareness about certain issues and even introduce specific skills, but without learners' regular application of knowledge and skills they are unlikely to gain significant proficiency with them. Sterling compares the instrumental and intrinsic views of education for sustainability [34]. The early approach/conceptualisation of ESD primarily presented an instrumental view that focused on raising awareness and promoting attitude change as a means to influence learners towards pro-sustainability behaviours. The intrinsic view of ESD is promoted as a contrasting approach that aims to move away from the "prescriptive tendencies" identified in the instrumental view. The intrinsic view places more focus on the educational process rather than the sustainability contents, and it addresses the provision of rich learning experiences to support critical reflection, contextualisation of knowledge, and experiential learning. "So whilst instrumental educators see sustainability as an identifiable state which can be educated for, intrinsic educators in contrast see the learning process as an intrinsic and vital part of sustainable development which cannot be known in advance or predetermined" [34].

Sterling goes on to explain that an intrinsic view of ESD works to build learners' capacities to think critically, systematically and reflexively. "From a resilience standpoint, one of the strengths of the 'intrinsic' view is that it attempts to promote 'adaptive capacity' in the learner in the face of uncertainty" [34]. Learning for adaptive capacity though requires more than basic experiential or action learning, as just repeating the same practice in the same context is not enough to gain real mastery of these skills. In order for learners to develop and gain proficiency with the key competencies for sustainability [5], the educational approach must support the application and adaption of knowledge, skills and values to a wide array of practical experiences and real-world issues.

Phenomenological studies of human learning demonstrate that the learning of various "skills" is a multi-faceted process where individuals pass through multiple stages or levels of skill-attainment and mastery. For example, the Dreyfus model of skill acquisition [35,36] proposes five

stages that learners pass through in the course of skill acquisition. "They are levels, say Dreyfus and Dreyfus, because in phenomenological terms they consist of recognizable, qualitatively different ways of acting and performing in the process of learning a given skill" [37]. In their later work, the five levels of their human-learning process model are updated as follows: Novice, Advanced beginner, Competent performer, Proficient performer, and Expert [36].

Flyvbjerg draws on the Dreyfus model in his work on *phronesis*, i.e. practical wisdom gained through experience (based on Aristotle's distinction of three intellectual virtues – *episteme*, *techne*, and *phronesis*) [37]. He notes that at the middle level of competent performer one of the notable changes is the development of "a relationship of involvement" [37]. Where in the previous two levels, novices and advanced beginners mainly act in accordance with fixed instructions or learned rules, at the level of competent performer actors become personally invested in their actions, conduct greater situational analysis and more strategically plan their actions. For the expert though, a level of "intimate experience" is achieved and the actor is able to act fluidly and intuitively so that their practice of assessment/analysis, problem solving and decision-making become effortless, or even appear to be non-existent. Flyvbjerg uses this divide in the Dreyfus model between rule-based, context-independent behaviour (found in the first three levels) and experience-based, situational behaviour (found in the last two levels) to discuss how most traditional forms of social science research are focused on the types of knowledge generated at the first three levels of this model. He then challenges that social sciences need to develop a *phronetic approach* if they are to investigate the types of knowledge (or wisdom) generated at the proficient performer and expert levels of cognitive development [38]. "On closer examination, the qualitative difference between rule-based and experience-based behaviour shows itself to have radical consequences, in that every rule-based, rational mode of conceiving of human activity – be this activity scientific, practical, or didactic – collapses when confronted with the Dreyfus phenomenology" [37]. Flyvbjerg's *phronetic approach* counters the more common epistemological tradition and empirical method, and instead encourages the exploration of the more intuitive knowledge and actions that a person gains after significant practice and experience within a given situation.

An overarching goal of both ESD and DRR education is to prepare learners to address the emerging, complex challenges that the world is facing and to be able to do so by charting a course of transformative social change. Flyvbjerg's arguments raise deep questions about the educational perspectives and approaches that are needed to achieve this goal, e.g. can we empower learners as agents of change or achieve real transformative learning for sustainable development if education does not support learners to reach these higher levels of experience-based, situational behaviour. The use of adaptive capacity in this work tries to understand the concept from this higher order cognitive development where a level of expertise is indicated by situational behaviour based on intimate experience and employs an intuitive understanding that is both holistic and interpretive in its nature. This perspective also raises specific questions regarding the current competency focus in ESD [5,39–42] in the sense that it demonstrates that cognitively competence development is succeeded by a level of proficient application and mastery. Notably, the pedagogical discussions about ESD practice have moved beyond a focus on knowledge, skill and value acquisition that was still common less than a decade ago and more towards a focus on effective competency development. However, there remains a lack of pedagogical discussion on the relationship between specific teaching methods and the resultant competency development. A *phronetic* understanding of learning for adaptive capacity highlights the importance of educational approaches that help to achieve experience-based, situational behaviour, and we argue here that the action-based approaches of ESD can be coordinated in a layered manner to support progressive competency development over time.

3. Key pedagogical aspects of learning for adaptive capacity

This section explores the key pedagogical aspects of *learning for adaptive capacity*. While these features are being proposed based on a theoretical literature review, they require further testing and validation in future studies. Both ESD and DRR education have a strong practice orientation to support the application of knowledge and skills to real-world settings, and equally they both include a perspective towards social learning processes. For example, ESD is noted for its contributions in making connections between learned knowledge and local contexts [2] and its focus on socio-cultural processes of meaning making [7]. A study of DRR education across 30 countries notes the importance of learning that, “brings knowledge to life, practices skills, challenges attitudes and scrutinizes values (and) is a pedagogy that is active, interactive, experiential and participatory” [10]. It is exactly these dimensions to make learning relevant to today’s world and to strengthen learners’ capacities to respond to global challenges in positive ways that have been identified as the key linkage between quality education, ESD and DRR education [43].

Previous studies have examined how pedagogical design and approaches strengthen sustainability learning [44–47]. For example, Segalàs, Ferrer-Balás and Mulder conclude, “Comparing the learning outcomes with the pedagogical approach used in each case study demonstrates that the more active the learning, the more focused on community and the more constructive, the higher the cognitive learning achieved by students” [44]. While the specific attributes of ESD and DRR education differ, both share a predisposition to similar pedagogical aspects. Five pedagogical aspects are identified and examined. The *practice orientation* considers the experience base the pedagogical design offers and the application of learning that is supported. The *interpretive approach* considers the framework for meaning making and knowledge codification that the pedagogy encourages. The *social perspective* considers what types of interaction between learners are supported by the pedagogical design. The *goal alignment* considers what is the main use/purpose of learning encouraged by the pedagogy. The *value basis* considers the core principle(s) underscoring the pedagogical design.

ESD and DRR share these five pedagogical aspects, but also demonstrate nuanced differences. ESD’s *practice orientation* is a general emphasis on action and experiential learning, whereas DRR education has a more specified focus on risk experience. ESD’s *interpretive approach* promotes systems thinking and holistic interpretations of knowledge, and DRR education promotes factor analysis and risk analysis. For their *social perspective*, while DRR education centres around collaborative resource and knowledge management, ESD points towards cooperative learning and social learning. ESD has a *goal alignment* towards problem solving and the search for solutions/innovations and a *value basis* for socially aware and responsible citizens. DRR education has a *goal alignment* towards risk reduction and self-protection and a *value basis* for resilience and disaster prevention.

Comparing the differences and similarities between these key pedagogical aspects can provide further definition to how learning for adaptive capacity can be designed [see Table 1]. The proposed pedagogical aspects of learning for adaptive capacity aim to align the aspects

of both ESD and DRR education towards a common learning objective. In this manner, learning for adaptive capacity requires the ability to relate learned knowledge to new situations through reflective assessment and to act in accordance with the context of a given (and changing) situation. In order to support this, learning for adaptive capacity may be seen to have a *practice orientation* towards critical reflection and practice (i.e. critical praxis) and an *interpretive approach* focussed on pattern recognition and identifying points of intervention within systems. With a goal to support individual and collective efforts to reimagine the future and envision sustainable and resilient pathways, learning for adaptive capacity’s *social perspective* aims to create communities of practice. To further strengthen the action-reflection cycle, learning for adaptive capacity also demonstrates a *value basis* framed around iterative and discursive meaning making. Learning for adaptive capacity ultimately aims to support effective and advantageous change at individual and social levels, and this is practically supported with a *goal alignment* towards resourcefulness, security and well-being.

The five pedagogical aspects of learning for adaptive capacity (Fig. 1) provide a functional understanding to orient both educational policy and pedagogical design towards learning processes for the development and proficient application of key competencies by both individuals and communities in change efforts to achieve greater resilience and sustainability. Community of practice theory [48,49] provides an entry point for collective action, and it highlights the development of mutual engagement, reflective exploration and a common repertoire as enabling conditions. Critical praxis [50,51] supports an experiential learning cycle with active engagement in reflection and practice to strengthen the testing, application and adaption of knowledge and skills. Establishing iterative and discursive understanding is based on a process of communicative action [52], discursive communication [53], and deliberative democracy [54] in which people collectively discuss and reflect on their interpretations and through which opportunities to create new forms of understanding are possible. These first three aspects (i.e. community of practice, critical praxis, and iterative and discursive understanding) are mutually reinforcing, and they have previously been identified as primary factors in achieving transformative social learning in an ESD context [8,55]. While community of practice may be primarily understood as a set of social conditions or a social process, both critical praxis and iterative/discursive understanding may be seen as enablers of this process that depend both on individuals’ skills, values and competencies as well as prevailing social institutions/systems. Together, these three pedagogical aspects strengthen a learning process oriented towards community discourse, reflection and practice that accentuates phronetic learning at both individual and collective levels by providing a basis for gaining proficient application of sustainability competencies.

The remaining two aspects of learning for adaptive capacity (i.e. pattern recognition and resourcefulness, security and well-being) primarily focus on individual learners – the competencies they hold and the perceptions that shape their world-views. A key competency for adaptive capacity is the ability to think holistically and to think systematically [56], and the related skills of pattern recognition and identifying points of intervention within systems supports the timely and appropriate application of adaptive capacity in both ESD and DRR

Table 1

Comparison of key pedagogical aspects for ESD, DRR education, and Adaptive Capacity.

	ESD	DRR education	Adaptive Capacity
Practice orientation	Action learning and experiential learning	Risk experience	Critical reflection and practice (i.e. critical praxis)
Interpretive approach	Systems thinking and holistic interpretations of knowledge	Factor analysis and risk analysis	Pattern recognition and identifying points of intervention within systems
Social perspective	Cooperative learning and social learning	Collaborative resource and knowledge management	Community of practice
Goal alignment	Problem-solving and search for solutions/innovations	Risk reduction and self-protection	Resourcefulness, security and well-being
Value basis	Socially aware and responsible citizens	Resilience and disaster prevention	Iterative and discursive meaning making

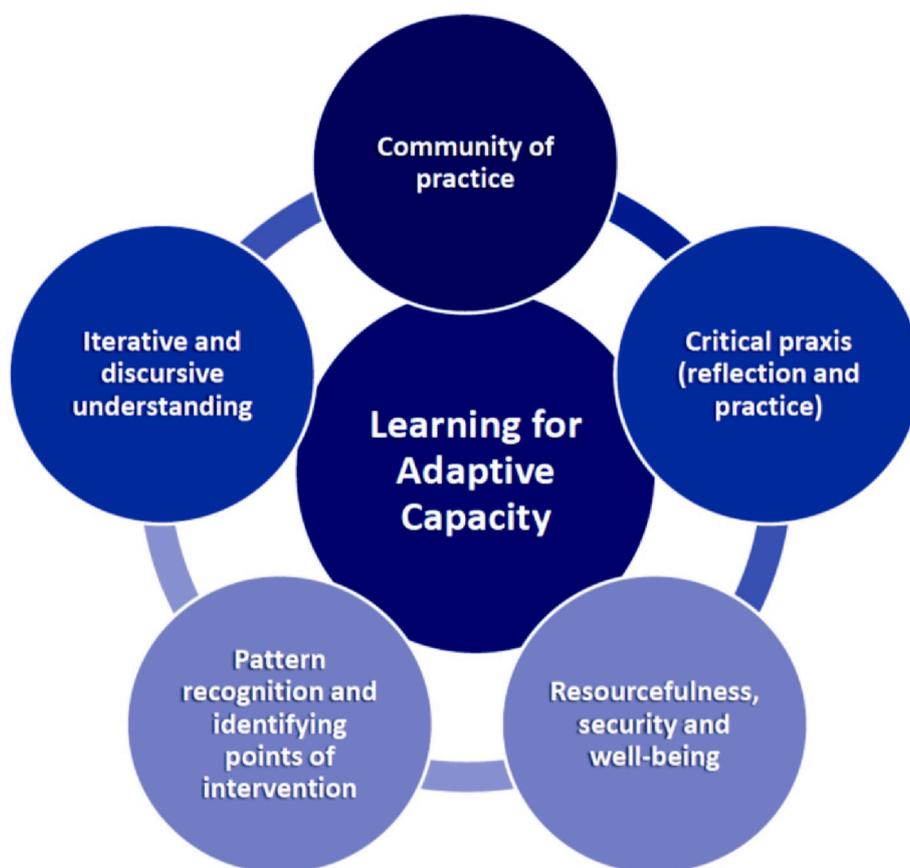


Fig. 1. Learning for adaptive capacity – pedagogical aspects.

perspectives. The goal alignment towards resourcefulness, security and well-being provides a combined view for resilience and sustainability. A dual-meaning exists for resourcefulness in terms of social and ecological interpretations; the social dimension is focussed on both flexibility and ingenuity at individual and collective levels, while the ecological dimension is focussed on increasing the abundance and resilience of natural resource systems. A more simple way to explain this use of resourcefulness would be ‘making the best and most out of the situation at hand’. The aspects of security and well-being are more directly linked as part of Sterling’s three nested stages of sustainability that starts with *survival* – then moves to *security* – and finally *well-being*, where each of the later stages depends on the previous stage as a primary condition [34]. While survival is of course primary to the later two levels, the goal alignment towards security and well-being has important connotations in the context of DRR education, as well as ESD. The proposed *interpretive approach* and *goal alignment* provide a lens through which situational-based learning and understanding can be oriented towards resilience and sustainability.

4. Examples of learning for adaptive capacity in practice

In this section, four DRR education cases from secondary literature are examined in relation to their practical application of learning for adaptive capacity. Several empirical studies have shown a causal relationships between education and disaster risk reduction which is indicated by an increase of adaptive capacity [15,57,58]. While these studies note that additional formal education can provide general advantages for lowering disaster vulnerability (due to wider skill development, better social and economic conditions, higher awareness of risk, increased cognitive ability, etc.), they also demonstrate that quantitative increases in education alone fail to achieve the noted increases in adaptive capacity. In fact, Muttarak and Pothisiri argue that there is

need for deeper and more qualitative investigations into the influence of formal education on disaster preparedness and risk response in order to gain an understanding of what leads to effective practice in DRR education [15].

This section therefore provides real-world cases that demonstrate a level of learning for adaptive capacity in order to further consider what the key pedagogical aspects look like in practice and explain how the concept can provide a functional objective for the enhancement of ESD and DRR education. The cases were selected with a positive bias and as conforming cases that exemplify the pedagogical aspects of learning for adaptive capacity. These cases provide examples of how these aspects are addressed in real-world educational practice, but due to the selective nature of the cases they should not be treated as a random, or even typical, sample nor as correlative evidence.

Sendai: An observational analysis describes cases from three Japanese universities [59] and includes a post-disaster DRR education related to the earthquake and tsunami disaster that occurred during the Japanese Triple Disaster in March 2011. In response, student teachers from Miyagi National University of Education (MUE) in Sendai, Japan who were pursuing ESD as a sub-major became actively involved in several post-disaster activities. They arranged educational trips to the disaster-stricken zones. The students who came from these zones served as the guides and introduced the participants to their (former) cities. These trips promoted social interaction between the university students, the visitors and the local communities. Under rather difficult emotional circumstances, the trainee teachers were able to apply their theoretical ESD knowledge previously obtained during lectures and relate this to their own experiences. This supported a stronger interplay between theory and critical inquiry by including reflexivity and self-reflection. With special emotional attachment to the impacted areas, the students felt a need to support the area’s rehabilitation, and some of the student teachers volunteered to assist local teachers and teach students from the

affected schools in the area [59].

Nihonmatsu: The same observational analysis also includes a DRR education case related to the man-made, nuclear accident that was also part of the Japanese Triple Disaster [59]. Following the disruption of the electricity supply due to the earthquake and tsunami, a crisis began at the nuclear power plant in Fukushima Prefecture that quickly escalated into severe accident that resulted in radiation contamination over of a large area. Responding to this, a research team (part of which comprised students) from Tokyo University of Agriculture and Technology (TUAT) worked in Nihonmatsu City to assess the actual situation of radiation pollution and to identify possible solutions for community rehabilitation. The university started organising study visits for students under the education program “Field-oriented Leaders in Environmental Sectors” (FOLENS) to the affected area that involved staying at local farms. By providing the students and faculty with a series of pre-visit briefings in the form of lectures and workshops to learn about the extent of radiation contamination and other problems related to the nuclear meltdown, participants had a better grasp on the scale and impact of the disaster. While the participants helped in the recovery work during their stay with local farmers affected by the disaster, they learned a significant amount through direct experience and through active discussions. In addition, reflection on these interactions supported linking real-world experience with previous teaching. The students also conducted a ‘participatory community study’ with local community members, and they walked around and talked to many individuals in order to create a local map that recorded important information including the community’s geographical, cultural, and human resources. At the end of their stay, the students presented their outputs comprising the created maps and their proposals for community recovery to the local residents. The outcomes of this process include: 1) students and faculty gained an opportunity for critical review of the disaster from various perspectives; and 2) the local community members, having received empathy and solidarity from the students, opened up to freely express their views, re-evaluate their situation, and use the bi-directional information obtained during the interactions to re-orient/re-design their future [59].

Yogyakarta: The problem of polluted rivers and periodic flooding in Yogyakarta, and many riparian towns and cities in Indonesia, has been identified as a serious challenge that is in part caused by the closeness of settlements to the rivers (including frequent habitation of flood plains) and the treatment of the rivers as a medium for waste disposal. The case of the Indonesian River Restoration Movement (IRRM) is premised on ESD principles [60]. IRRM promotes multi-stakeholder community learning for disaster risk reduction (e.g., removal of encroaching houses, desilting riverbeds and removal of garbage to address flooding) and preparedness (e.g., establishing river schools to build capacities of youth to work for community resilience, expanding the project to other communities, and connecting these communities through a larger network). Researchers from the University of Gadjah Mada decided to start from a basis of voluntary, active participation with the aim to create a “movement for change”. The main objectives were to learn, to act and to solve problems with the local communities collaboratively to realise rivers that are clean, healthy, productive, safe and well conserved. Groups worked to achieve this through river clean-up, replanting of flora along the river for restoration and removal of houses from the river flood plains, and they did this while encouraging a spirit of love, togetherness, harmony, and motivation. The public and private sectors also signed up to this expansive project, and it now supports a growing number of River Schools – a major product of the movement that have environmental and DRR education at their core. Pedagogical approaches used include: i) systemic approach: involving/incorporating knowledge from all stakeholders; ii) networking approach: strengthening connection within and across each stakeholder group, over large areas, and expanding across the archipelago; iii) e-communication approach: using mobile phones and social media; iv) community-based approach: premised on the SDGs; and v) knowledge-based approach: using ESD. The IRRM has led to more educated communities with a change in attitudes from apathy to

respecting, loving and preserving the river. Furthermore, it is a movement that has rapidly spread to communities across Indonesia and is resulting in clean, restored and protected rivers [60].

Rio de Janeiro: This study was conducted to examine how people’s risk from climate-related disasters was influenced by their level of formal education in Rocinha favela in Rio de Janeiro, Brazil, where floods and landslides are recurrent [61]. As such, this study provides valuable evidence on the importance of formal education in determining the adaptive capacity for the residents of an informal settlement. Three highly relevant points were reported among the results. First, respondents with (relatively) higher levels of education were more informed about existing risks. These respondents evacuated more efficiently in times of emergency, and they also thought differently about where to settle and would usually opt for safer alternatives during the post-disaster recovery stage. Second, educated people were more informed and had more means to: i) express themselves and better utilise the existing social structure, thus being listened to more by other people including the authorities, and ii) use legal mechanisms, argue their rights, and search out and make use of available opportunities to address their situation. Formal education was found to play a significant role in determining people’s level of risk reduction and coping abilities. Also, formal education was seen to have a mitigating effect on negative factors that exacerbate people’s level of risk, and higher levels of education strengthen people’s awareness and understanding of existing risks [61].

These cases are now explored in relation to the pedagogical aspects of learning for adaptive capacity:

Critical praxis (practice orientation): Students from MUE (*Sendai*) engaged in critical praxis by relaying their theoretical ESD knowledge, skills and competencies with actual experience in the field. Due to their strong emotional attachment to the affected areas, critical inquiry and reflexivity was enhanced towards situational-based application of competencies. The TUAT students (*Nihonmatsu*) gained both direct interaction with disaster victims and the opportunity to conduct a critical review of the incident from various perspectives through a series of lectures and discussions. The critical praxis led to a deep examination of the realities facing communities in post-disaster periods. Researchers in the IRRM project (*Yogyakarta*) spearheaded the creation of a multi-stakeholder “movement of change” to address urgent sustainability issues facing vulnerable communities by connecting and integrating theoretical expertise with the identification of practical interventions.

Pattern recognition and identifying points of intervention within systems (interpretive approach): By volunteering to assist teachers to teach students from the affected schools in the disaster area, MUE students (*Sendai*) identified both a recurrent problem and a point of intervention to address it. Similarly, TUAT students (*Nihonmatsu*) created system maps of local resources and used this knowledge to identify intervention points and develop proposals for community recovery. IRRM stakeholders (*Yogyakarta*) pooled together available expertise in the project, and using a systemic pedagogical approach, they developed a holistic and multi-dimensional response. The educated Rocinha dwellers (*Rio de Janeiro*) were more able and likely to identify effective personal interventions, and afterwards search and make use of the available opportunities to improve their situation.

Community of practice (social perspective): The social interaction promoted between the MUE students, the visitors and the local communities (*Sendai*) showed simplified elements of a community of practice through the project’s effort to support collaborative learning. Premised on ESD principles, the multi-stakeholders of IRRM project (*Yogyakarta*) collaborated in DRR education, preparedness, and in an effort to establish a new perspective and new solutions, thereby portraying an effective community of practice. The community-based approach to project implementation, the networking of stakeholder groups across levels, and the use of a common value set in promoting active participation in the IRRM project all demonstrate features of a community of practice.

Resourcefulness, security and well-being (goal alignment):

Students from MUE (*Sendai*) availed their resourcefulness by engaging in the university's post-disaster activities to solve real problems, to reduce risk, and to help the victims recover from the disaster. Similarly, TUAT students (*Nihonmatsu*), through their resourcefulness were able to develop maps and proposals that were innovative and problem solving for community recovery. The IRRM project participants (*Yogyakarta*) developed a strategy of concrete action to achieve their goal of a clean, productive, safe and protected river. The more educated and hence informed in Rocinha (*Rio de Janeiro*) were relatively more able to utilise the social structure to their advantage and in terms of human rights, more likely to access supportive legal and institutional mechanisms, thus achieving an enhanced level of security and well-being.

Iterative and discursive meaning making (value basis): The repeated trips made by MUE students (*Sendai*) to the disaster zone to talk about their affected cities and interactions with members in their communities made their experience more meaningful and enhanced their social awareness. TUAT students (*Nihonmatsu*) collaborated with disaster victims in research and education, thus allowing the group to obtain a meaningful understanding of the reality at hand and develop a more critical and holistic perspective on the situation. In turn, this supported the communities in developing a higher level of adaptive capacities. The disaster victims, through bi-directional interactions with students and faculty were able to freely express their views, re-evaluate their own situation, and use the information and resources obtained to redesign their future. The IRRM project (*Yogyakarta*) has resulted in a more educated community and an attitude and behaviour change from apathetic to active citizenship.

5. Discussion

This paper argues for greater alignment between ESD and DRR education, and it proposes that these two educational perspectives can work together to improve the relevance and quality of education. Learning for adaptive capacity is presented as an educational objective for ESD and DRR education that can support their improved pedagogical design and strengthen linkages with quality education – especially in terms of its orientation towards intrinsic learning and the relevant application of learned knowledge, skills, and competencies for addressing real-world challenges and issues. “In principle, ESD challenges policy-makers to go beyond the links between ESD and content-oriented educational priorities and to consider how education can contribute to greater sustainability in the economic, labour market and industrial sectors” [62].

While the current competency focus in ESD [5,39–42] has gained much attention both in literature and in practice, it is also notable that much of the literature on sustainability competencies avoids discussing how pedagogical methods and teaching approaches support their development. Sustainability competencies play a key role in ESD and are important in providing a target focus towards delivering quality education. However, they alone do not provide significant guidance in relation to the pedagogical design of quality ESD and its teaching, nor how learners are to gain the capacity for the proficient application of these competencies.

For example, while there has been a growing number of sustainability-oriented degree programmes in higher education, existing efforts to assess (and provide empirical evidence) of the competency building achieved from these programmes has been wanting [63]. Trencher et al. review the performance of 14 sustainability-related masters programmes in relation to their competency building effectiveness, following the competency framework developed by Wiek, Withycombe, and Redman [64]. In general, the programmes achieved a *satisfactory* or *effective* level of competency development, but none of the programmes achieved a *very effective* level. While the study did not account for differences in pedagogical styles or approaches across the programmes, the results do show that practice-oriented programmes achieved higher competency building effectiveness than

research-oriented programs. Trencher et al. suggest that research-oriented programmes may need to integrate more of the practice-oriented strategies and approaches if they want to increase competency development, especially in relation to building learners' practical skills and methods [63].

This is not to discredit the value of these competencies as a strategic objective for ESD. In fact, such competencies, like those identified by Wiek, Withycombe, and Redman: systems thinking competence, anticipatory competence, normative competence, strategic competence, and interpersonal competence [64] are understood as a fundamental part of learning for adaptive capacity and can easily be aligned with the presented pedagogical aspects. The framework of learning for adaptive capacity supports a pedagogical design and teaching approach aimed at both substantive competency development and the proficient application of these competencies across diverse contexts in both individual and collective situations.

Learning for adaptive capacity employs a *phronetic approach* to consider how pedagogical strategies can support and strengthen competency development by providing structured opportunities for practice and experience, coupled with critical reflection, in a progressive and accumulative manner. Bardone and Bauters suggest that, “what phronesis looks at is more the way in which theory – in all its different forms – can actually be used by practitioners in the attempt to enlarge, broaden and deepen the basis of one's experience” [65]. The provision of real-world learning opportunities, for example, has been linked to improved competency building effectiveness in sustainability courses [66]. A phronetic approach can serve as a, “means of helping communities to understand, confront, and find contextually appropriate solutions to the challenges they face” [67], and applied as a pedagogical strategy it should target practical approaches to apply methods and skills across diverse contexts and settings, in order to both strengthen competency development and the flexible application of these competencies.

When considering how to improve the overall quality education (especially in relation to sustainable development and DRR), there are four main goals to be addressed: 1) applying a well-developed curriculum, 2) improving the quality of teaching methods, 3) establishing a safe and effective learning environment, and 4) inspiring cooperative and transformative learning [68]. It is possible to link each of the quality education goals to the learning objective for adaptive capacity. The application of a well-developed curriculum is focused on *what people learn*. In relation to adaptive capacity, this should of course ensure the inclusion of relevant content and knowledge related to DRR and sustainable development. The curriculum though should also be structured to ensure effective depth learning and aim to apply a *phronetic approach* to learning. Depth learning is supported by deep investigation into individual subjects, but it is also strengthened through *critical praxis* which improves the connections between classroom learning and real world practice. Furthermore, depth learning can be supported with progressive (or scaffolded) learning objectives that ensure knowledge and skill development over time through iterative and incremental improvements. Working at the intersection of quality education, sustainable development and DRR, the overall focus is on the adaptable application of skills and competencies to differing situations and contexts in a relevant and appropriate manner.

The curriculum is the place to also address the *interpretive approach* and *goal alignment* of learning for adaptive capacity, i.e. the abilities for *pattern recognition and identifying intervention points*, and *resourcefulness, security and well-being*. While pattern recognition and identifying points of intervention build from the systems thinking competency, these specific attributes demonstrate a more advanced ability that usually develops as part of phronetic learning and applying this competency over a diversity of situations. There are relevant skills though that can be taught, for example:

- In mathematics, simple pattern recognition is done both with numbers and shapes,
- In learning about weather and climate, there are many observable patterns including signals of weather shifts such as a sudden temperature and pressure drop before rain.
- Natural systems can be examined in terms of system balances and imbalances as well as what chain of reactions occur when an imbalance happens, and
- Learning to use a SWOT (strengths, weaknesses, opportunities and threats) analysis when reflecting on various social systems is a way to learn skills to identify intervention points.

Resourcefulness, security and well-being need to be more reflected within the curriculum as a goal alignment in the way they are linked throughout lessons and classroom culture, and this has strong links to the development of value-based learning and the use of cooperative learning methodologies.

Improving the quality of teaching and learning methodologies is focused on *how people learn*. In terms of adaptive capacity, this strongly aligns with the *value basis* and the *practice orientation*. For this, a pedagogical perspective concerned with *critical reflection/practice* and *iterative, discursive meaning making* is required. Problem-solving activities is one learning approach that supports critical reflection and practice, but examination of case studies and good practice examples to identify what did and did not work is another way to support a level of praxis. Iterative and discursive meaning making are supported through activities that require group dialogue and collaboration, and equally valuable can be the examination of multi-cultural perspectives and views. Introducing more participatory and active learning approaches also depends on the improvement and expansion of teacher training to yield teachers who are competent in interdisciplinary and team teaching, group learning and collaborative investigation approaches, and student-centred learning approaches.

The establishment of safe and effective learning environments is concerned both with *where and with whom people learn*. In regards to where people learn, the safety of the school is primary. DRR principles should be included in the design and management of the school facilities/environment (for example, employing a comprehensive school safety framework [12]), and democratic engagement in the decision-making and planning for risk reduction and resilience should be normalised in the school culture. The overall effectiveness of the learning environment goes beyond this though, and here the main synergy for quality education and learning for adaptive capacity is related to the *social perspective* that is facilitated and institutionalised. With the objective of achieving a *community of practice*, schools should ideally create an ethos where education and learning are seen as the collective responsibility and the totality of all involved actors (i.e. students, teachers, administrators, staff, parents, etc.) working together. In building up a process of social learning, it is useful to consider how learning extends beyond the classroom and into the wider community. The school environment may also be built and designed to support active and experiential learning, as well as providing space for group collaboration and reflection. Opportunities may further be developed to engage in real world learning through community-based projects and exploration of local ecosystems.

Finally, inspiring transformative and cooperative approaches to teaching/learning addresses *in what context people learn*. This goal of quality education is concerned with the overall paradigm of learning that is shaped by the educational process, and it is linked to the type of world-view and framework for understanding that is facilitated by this paradigm. Learning for adaptive capacity may be denoted as the overarching learning paradigm discussed in this paper, and the five pedagogical aspects provide the foundation for this paradigm. However, the need to develop a *phronetic approach* is also important for this goal as it will be the systematic advancement of these pedagogical aspects over time and across context that will provide a basis for transformative

learning.

The key aspects of learning for adaptive capacity presented in this paper will require investigation in applied educational studies to further clarify and validate their functionality in actual practice. Due to the limitations of this paper, there are several dimensions that have not been possible to explore that relate to individual capacity development and how they would apply in the context of adaptive capacity. For example, we acknowledge that psychological constraints [20] and emotional abilities to cope with change [14,69] can be important factors in adaptation practices, and in future work the interlinkages between learning for adaptive capacity and development of psychological and emotional abilities to deal with the turmoil created by transformative learning and adaptive change will be of high importance. The value that both creativity and flexibility have in relation to a person's adaptive capacity also deserve further attention. In aligning educational policy and practice towards learning for adaptive capacity, it is also necessary that additional consideration is given to how adaptive capacity can be addressed through educational assessment, due to the common fact that what gets measured or tested is often actually the primary driving factor for what gets taught. In responding to the critical challenge of how education can prepare learners to survive and prosper in a world of change, the concept of learning for adaptive capacity has been elaborated as a common learning objective for ESD and DRR education that can support a pedagogical design/approach that advances the overall quality of education and prepares learners to cooperate for "transforming our world".

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.ijdr.2020.101631>.

References

- [1] UN General Assembly Resolution A/RES/70/1, Transforming Our World: the 2030 Agenda for Sustainable Development, 2015.
- [2] R. Laurie, Y. Nonoyama-Tarumi, R. McKeown, C.A. Hopkins, Contributions of education for sustainable development (ESD) to quality education: a synthesis of research, *J. Econ. Sustain. Dev.* 10 (2016) 1–17.
- [3] R.J. Didham, P. Ofei-Manu, The role of education in the sustainable development agenda: empowering a learning society for sustainability through quality education, in: *Achieving the Sustainable Development Goals: from Agenda to Action*; Institute for Global Environmental Strategies, Institute for Global Environmental Strategies, Hayama, 2015, pp. 95–133.
- [4] R.J. Didham, P. Ofei-Manu, Advancing policy to achieve quality education for sustainable development, in: A. Leicht, J. Heiss, W.J. Byun (Eds.), *Issues and Trends in Education for Sustainable Development*, UNESCO, Paris, France, 2018, pp. 87–110, 978-92-3-100244-1.
- [5] UNESCO, *Education for Sustainable Development Goals: Learning Objectives*; Paris, 2017.
- [6] P. Ofei-Manu, R.J. Didham, Identifying the factors for sustainability learning performance, *J. Clean. Prod.* 198 (2018) 1173–1184.
- [7] H. Lotz-Sisitka, Conceptions of quality and 'learning as connection': teaching for relevance, *South African J. Environ. Educ.* 29 (2013) 25–38.
- [8] H. Lotz-Sisitka, A.E.J. Wals, D. Kronlid, D. McGarry, Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction, *Curr. Opin. Environ. Sustain.* 16 (2015) 73–80.
- [9] R. Lozano, M.Y. Merrill, K. Sammalisto, K. Ceulemans, F.J. Lozano, Connecting competences and pedagogical approaches for sustainable development in higher education: a literature review and framework proposal, *Sustain. Times* 9 (2017).
- [10] UNESCO; UNICEF Disaster, Risk Reduction in School Curricula: Case Studies from Thirty Countries; Geneva, 2012.
- [11] *Disaster Education*, R. Shaw, K. Shiwaku, Y. Takeuchi (Eds.) Volume 7, Emerald, Bingley, 2011.
- [12] *Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector Comprehensive School Safety*, A global framework, Geneva, 2017.
- [13] A. Amri, K. Haynes, D.K. Bird, K. Ronan, Bridging the divide between studies on disaster risk reduction education and child-centred disaster risk reduction: a critical review, *Child Geogr.* 16 (2018) 239–251.

- [14] P.T. Apronti, S. Osamu, K. Otsuki, G. Kranjac-Berisavljevic, Education for disaster risk reduction (DRR): linking theory with practice in Ghana's basic schools, *Sustain. Times* 7 (2015) 9160–9186.
- [15] R. Muttarak, W. Pothisiri, The role of education on disaster preparedness: case study of 2012 Indian ocean earthquakes on Thailand's Andaman Coast, *Ecol. Soc.* 18 (2013) 1–16.
- [16] M. Benadusi, Pedagogies of the unknown: unpacking "Culture" in disaster risk reduction education, *J. Contingencies Crisis Manag.* 22 (2014) 174–183.
- [17] J. Mercer, I. Kelman, K. Lloyd, S. Suchet-Pearson, Reflections on use of participatory research for disaster risk reduction, *Area* 40 (2008) 172–183.
- [18] W.N. Adger, Social aspects of adaptive capacity, in: *Climate Change, Adaptive Capacity and Development*, 2003, pp. 29–49.
- [19] B. Smit, O. Pilifosova, From adaptation to adaptive capacity and vulnerability reduction, in: *Climate Change, Adaptive Capacity and Development*, 2003, pp. 9–28.
- [20] T. Grothmann, A. Patt, Adaptive capacity and human cognition: the process of individual adaptation to climate change, *Global Environ. Change* 15 (2005) 199–213.
- [21] B. Smit, J. Wandel, Adaptation, adaptive capacity and vulnerability, *Global Environ. Change* 16 (2006) 282–292.
- [22] M.E. Keim, Building human resilience. The role of public health preparedness and response as an adaptation to climate change, *Am. J. Prev. Med.* 35 (2008) 508–516.
- [23] L. Schultz, C. Lundholm, Learning for resilience? Exploring learning opportunities in biosphere reserves, *Environ. Educ. Res.* 16 (2010) 645–663.
- [24] R. Shaw, *Community Practices for Disaster Risk Reduction in Japan*, Springer Science & Business Media, 2014, ISBN 4431542469.
- [25] K.G. Tidball, M.E. Krasny, From risk to resilience: what role for community greening and civic ecology in cities, in: A.E.J. Wals (Ed.), *Social Learning: towards a Sustainable World*, Wageningen Academic Publishers, Wageningen, 2009, pp. 149–164.
- [26] D.E. Alexander, Resilience and disaster risk reduction: an etymological journey, *Nat. Hazards Earth Syst. Sci.* 13 (2013) 2707–2716.
- [27] C. Folke, S.R. Carpenter, B. Walker, M. Scheffer, T. Chapin, J. Rockström, Resilience thinking: integrating resilience, adaptability and transformability, *Ecol. Soc.* 15 (2010).
- [28] E. Striessnig, W. Lutz, A.G. Patt, Effects of Educational Attainment on Climate Risk Vulnerability, vol. 18, 2013.
- [29] R. Muttarak, W. Lutz, *Ecol. Soc.* (2014).
- [30] W. Lutz, R. Muttarak, E. Striessnig, Environment and development. Universal education is key to enhanced climate adaptation, *Science* 346 (2014) 1061–1062.
- [31] B. Walker, D. Salt, *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*, Island Press, Washington, DC, 2006.
- [32] J. Mezirow, *Transformative learning: theory to practice*, *N. Dir. Adult Cont. Educ.* 1997 (1997) 5–12.
- [33] J. Mezirow, Transformative learning as discourse, *J. Transformative Educ.* 1 (2003) 58–63.
- [34] S. Sterling, Learning for resilience, or the resilient learner? towards a necessary reconciliation in a paradigm of sustainable education, *Environ. Educ. Res.* 16 (2010) 511–528.
- [35] S.E. Dreyfus, H.L. Dreyfus, *A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition*, 1980.
- [36] H.L. Dreyfus, S.E. Dreyfus, T. Athanasiou, *Mind over Machine*, Simon and Schuster, New York, 2000.
- [37] B. Flyvbjerg, *Making Social Science Matter: Why Social Inquiry Fails and How it Can Succeed Again*, Cambridge University Press, Cambridge, United Kingdom, 2001, ISBN 978-0-521-77568-7.
- [38] B. Flyvbjerg, Social science and policy challenges - democracy, values and capacities, *Soc. Sci. Pol. Challenges - Democr. Values Capacit. Pol.* (2011) 25–56.
- [39] M. Barth, J. Godemann, M. Rieckmann, U. Stoltenberg, Developing key competencies for sustainable development in higher education, *Int. J. Sustain. High Educ.* 8 (2007) 87–98.
- [40] A. Wiek, L. Withycombe, C.L. Redman, Key competencies in sustainability: a reference framework for academic program development, *Sustain. Sci.* 6 (2011) 203–218.
- [41] G. Cebrián, M. Junyent, Competencies in education for sustainable development: exploring the student teachers' views, *Sustain. Times* 7 (2015) 2768–2786.
- [42] A. Wiek, B. Mj, F. R. W. M. Cohen, N. Forrest, C. Kuzdas, B. Kay, A. Wiek, M. J. Bernstein, R.W. Foley, et al., Operationalizing competencies in higher education for sustainable development, *Routledge B. High. Educ. Sustain. Dev.* (2016) 241–260.
- [43] UNESCO, *Shaping the Future We Want: UN Decade of Education for Sustainable Development (2005-2014) - Final Report*, UNESCO, Paris, 2014, ISBN 9789231000539.
- [44] J. Segalàs, D. Ferrer-Balas, K.F. Mulder, What do engineering students learn in sustainability courses? The effect of the pedagogical approach, *J. Clean. Prod.* 18 (2010) 275–284.
- [45] M. Missimer, T. Connell, Pedagogical approaches and design aspects to enable leadership for sustainable development, *Sustainability* 5 (2012) 172–181.
- [46] H. Burns, Meaningful sustainability learning: a study of sustainability pedagogy in two university courses, *Int. J. Teach. Learn. High. Educ.* 25 (2013) 166–175.
- [47] H.L. Burns, Transformative sustainability pedagogy: learning from ecological systems and indigenous wisdom, *J. Transformative Educ.* 13 (2015) 259–276.
- [48] J. Lave, E. Wenger, *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press, Cambridge, 1991, ISBN 0-521-42374-0.
- [49] E. Wenger, *Communities of Practice: Learning, Meaning, and Identity*, vol. 9, Cambridge University Press, Cambridge, 1998, 0521663636.
- [50] M. Ledwith, *Community Development: A Critical Approach*, Policy Press, Bristol, 2005.
- [51] M. Ledwith, J. Springett, *Participatory Practice: Community-Based Action for Transformative Change*, Policy Press, Bristol, 2010.
- [52] J. Habermas, *Theory of Communicative Action, Volume One: Reason and the Rationalization of Society*, Translated., Beacon Press, Boston, 1984.
- [53] J.S. Dryzek, *Discursive Democracy: Politics, Policy, and Political Science*, Cambridge University Press, Cambridge, United Kingdom, 1994.
- [54] J.S. Dryzek, *Deliberative Democracy and beyond: Liberals, Critics, Contestations*, Oxford University Press, Oxford, 2000.
- [55] R.J. Didham, P. Ofei-Manu, *Social Learning for Sustainability: advancing community-based inquiry and collaborative learning for sustainable lifestyles*, in: V.W. Thoresen, R.J. Didham, J. Klein, D. Doyle (Eds.), *Responsible Living: Concepts, Education and Future Perspectives*, Springer, Heidelberg, 2015, pp. 233–252, 978-3-319-15304-9.
- [56] D.H. Meadows, *Thinking in Systems: A Primer*, Chelsea Green Publishing Company, White River Junction, 2008.
- [57] U. Sharma, A. Patwardhan, A.G. Patt, Education as a determinant of response to cyclone warnings: evidence from coastal zones in India, *Ecol. Soc.* 18 (2013).
- [58] E. Frankenberger, B. Sikoki, C. Sumantri, W. Suriastini, D. Education Thomas, Vulnerability, and resilience after a natural disaster, *Ecol. Soc.* 18 (2013).
- [59] S. Ninomiya-Lim, S. Furihata, P. Ofei-Manu, Y. Kaminaga, Reorienting Japanese university education towards community resilience in the wake of disaster responsiveness, in: P.B. Corcoran, J.P. Weakland, A.E.J. Wals (Eds.), *Envisioning Futures for Environmental and Sustainability Education*, Wageningen Academic Publishers, Wageningen, 2017, pp. 311–320.
- [60] A. Maryono, Indonesian River Restoration Movement (IRRM) toward Education for Sustainable Development, (ESD), 2016.
- [61] Brink, E. Disasters, formal education and adaptive capacity - Does people's level of formal education influence their risk from climate-related disasters? A case study of an informal settlement in Rio de Janeiro. LUTVDG/TVBB—5349—SE 2010, Lund Univ., 1402–3504.
- [62] A. Benavot, *Education for Sustainable Development in Primary and Secondary Education*, Paris, 2014.
- [63] G. Trencher, S. Vincent, K. Bahr, S. Kudo, K. Markham, Y. Yamanaka, Evaluating core competencies development in sustainability and environmental master's programs: an empirical analysis, *J. Clean. Prod.* 181 (2018) 829–841.
- [64] A. Wiek, L. Withycombe, C.L. Redman, Key competencies in sustainability: a reference framework for academic program development, *Sustain. Sci.* 6 (2011) 203–218.
- [65] E. Bardone, M. Bauters, A phronetic approach to educational design-based research: issues and aspirations, *Educ. Des. Res.* 1 (2017).
- [66] K. Brundiers, A. Wiek, C.L. Redman, Real-world learning opportunities in sustainability: from classroom into the real world, *Int. J. Sustain. High Educ.* 11 (2010) 308–324.
- [67] T. Hargreaves, Questioning the virtues of pro-environmental behaviour research: towards a phronetic approach, *Geoforum* 43 (2012) 315–324.
- [68] P. Ofei-Manu, R.J. Didham, *Quality Education for Sustainable Development: A Priority in Achieving Sustainability and Well-Being for All* (IGES Policy Brief, No. 28), Hayama, Japan, 2014.
- [69] M. Pelling, C. High, J. Dearing, D. Smith, Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations, *Environ. Plan. A Econ. Sp.* 40 (2008) 867–884.