“Sustainability Learning”: An Introduction to the Concept and Its Motivational Aspects

Sustainability **2010**, *2*, 2873-2897; doi:10.3390/su2092873

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Review

"Sustainability Learning": An Introduction to the Concept and Its Motivational Aspects

Ralf Hansmann

Department of Environmental Sciences, Natural and Social Science Interface (NSSI), ETH Zurich, Sonneggstrasse 33, ETH SOL F.7, CH-8092, Zurich, Switzerland; E-Mail: hansmann@env.ethz.ch; Tel.: +41-44-632-6316; Fax: +41-44-632-1029

Received: 1 July 2010; in revised form: 28 August 2010 / Accepted: 3 September 2010 / Published: 13 September 2010

Abstract: This theoretical paper clarifies the concept of sustainability learning and specifically analyzes motivational aspects. Mastering the challenges of sustainability requires individual learning as well as learning processes on different levels of human systems ranging from groups and organizations to human societies, and mankind as a whole. Learning processes of individuals play a fundamental role, since individuals constitute and shape the larger social aggregates. Learning processes on the level of social aggregates are important since social systems embed and influence individuals. Therefore, sustainability learning needs to be understood as a multi-level concept, comprising individual learning as well as learning processes of human systems. Transdisciplinarity and mutual learning between science and society are considered fundamental approaches of sustainability learning, and hence increase the capacity of mankind to manage human-environment systems in sustainable ways. Based on systemic considerations, the two-fold role, in which motivations act as determinants and targeted outcomes of sustainability learning processes, is explained together with the outstanding role that cooperation, hence cooperative motivation, plays for sustainable development. Finally, the multifaceted, controversial discourses on what sustainability ultimately means (for the scientific community, for a given cultural or political entity, organization, or individual person) are considered.

Keywords: sustainability learning; motivation; affective; cognitive; learning goals; social learning; sustainability

---

1. Education and Learning as Requirements for Sustainable Development

Based on serious concerns about the deterioration of the environment and natural resources, the World Commission on Environment and Development (WCED) [1] demanded that goals of economic and social development must be defined in terms of sustainability. The UN [2] thus adopted sustainable development, which aims "to meet the needs and aspirations of the present without compromising the ability to meet those of the future" ([1], Chapter 1, 49) as a guiding principle. Various objectives such as preserving peace, remedying problems of poverty, addressing the problems of population growth, managing environmental risk, integrating environmental, social, and economic concerns in policy formation and decision-making, and an equitable sharing of the environmental costs and benefits of economic development between and within countries and generations were acknowledged as important normative aspects of sustainability.

Since the Brundtland report of WCED was published in 1987, the need for sustainable development has been increasingly acknowledged as expressed in the declarations of Rio [3] and Johannesburg [4]. The political momentum towards sustainable development has been accompanied in the scientific realm by the rapid growth of the new inter- and transdisciplinary field of *sustainability sciences* [5]. New science education programs, research institutions, and scientific journals centered on the concept of sustainability have emerged. University curricula focused on sustainability, as well as programs that integrate sustainability into existing scientific, engineering, industrial design, economics, social science, and other curricula have been developed [6-9].

However, even though the importance of *sustainability* has been widely recognized, the current intensity, scope, and characteristics of human activity are substantially unsustainable [10]. From the environmental perspective, desertification, forest degradation, loss of biodiversity, and global warming are examples of problems that have been aggravated during the last several decades [11,12]. Social and economic goals of sustainable development such as providing sufficient food and water to all people, and remedying poverty, have been unsatisfactorily realized, even though technological progress substantially enhanced economic productivity and thus, allowed for considerable economic growth, increased food production, and an increasing accumulation of economic capital in advantaged countries, companies, and by individuals. At present, negative interactions between environmental and socio-economic processes are negatively influencing the situation of many humans. Predictably, the harmful impact of such negative interactions will substantially deteriorate the circumstances of many humans in the future [13,14].

Effective strategies for promoting sustainability at the global and local level are needed, and there is broad consensus that education must be the driving force. According to Agenda 21, "Education […] should be recognized as a process by which human beings and societies can reach their fullest potential. Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues" ([15], Chapter 36).

A UNESCO report [16] on lessons learned about the contribution of education to sustainable development during the period from 1992 to 2002—*i.e.*, from Rio to Johannesburg—claims that education "is the most effective means that society possesses for confronting the challenges of the future" and "while education is not the whole answer to every problem, in its broadest sense, education must be a vital part of all efforts to imagine and create new relations among people and to foster

greater respect for the needs of the environment" (p. 7). The report criticizes educational approaches, which focus on the development of scientific and technical skills in an isolated way, and ignore matters of moral sensitivity and values, since "the movement towards sustainable development depends more on the development of our moral sensitivities than on the growth of our scientific understanding—important as that is" (p. 11). This critique seems consistent with Nazaretyan [17], who formulated a principle of *techno-humanitarian balance* arguing that the more technologically developed war and production technologies become, the more refined behavior regulation means are required for self-preservation of the society.

Technological strategies for promoting sustainable development are important. S*ubstituting* old technologies with new, environmentally friendly ones, or increasing the *eco-efficiency* of companies through taking life-cycle assessments into account in management decisions, are two examples of approaches that can reduce negative environmental impacts of production processes. However, technological approaches do not seem capable of achieving sustainable development when considered in isolation. Eco-efficiency is neither a sufficient. nor a necessary precondition, for sustainability [18]. For a wide range of environmental problems' strategies, aiming at sufficiency and self-limitation might be more promising than technological progress and efficiency strategies [19]. Individual and societal learning is needed in this context, since such strategies require changes in people's lifestyle, and depend on a social climate, in which a modest, simple lifestyle is more acceptable than an affluent, consumption-oriented one [20].

UNESCO reminds us that "education not only provides scientific and technical skills, it also provides the motivation, justification, and social support for pursuing and applying them. For this reason, society must be deeply concerned that much of current education falls far short of what is required" ([16], pp. 8-9). If sustainability is to be achieved, *sustainability learners* do not only need to analyze and find out what is sustainable, they also require the motivation to adopt sustainable courses of action. Motivations for pro-sustainability behaviors are therefore a central learning outcome of sustainability learning.

From a psychological perspective, the differentiation between educational objectives in terms of motivation and justification for sustainable action on the one hand, and scientific and technological knowledge on the other, closely corresponds to Bloom's [21] taxonomy of educational objectives which distinguishes (next to psychomotor learning) between a *cognitive* and an *affective domain* of learning goals [22-24].

The cognitive domain of the taxonomy refers to the enhancement of intellectual capabilities and knowledge, and hence includes the development of scientific and technological skills. The cognitive learning domain largely determines the paths of action individuals are intellectually capable of taking, and how far individuals can foresee the consequences of these actions.

The affective domain refers to attitudes and the organization of a person's value system. Imparting pro-sustainability values needs to be understood as the basis of pro-sustainability motivations and justifications, which influence behavioral decision-making within the frame of cognitively and technologically possible paths of action.

Enhancing learner's *environmental literacy* is acknowledged as a fundamental goal of sustainability communication and education [25-27]. Environmental literacy entails cognitive, social, value related, and behavioral aspects. It refers to an "individual's knowledge about, and attitudes toward, the

environment and environmental issues; skills and motivation, to work toward the resolution of environmental problems and active involvement in working towards the maintenance of dynamic equilibrium between quality of life and quality of environment" ([25], p. 232).

Thus, environmental literacy comprises a systemic understanding of the complex interactions between human activity and the natural environment, and awareness and knowledge of current environmental issues and problems, as well as social skills for tackling such problems, and values and motivations that bring about environmentally responsible behavior [26].

The field of sustainability communication and education is growing and a diversification of settings, topics, and formats has been taking place [28,29]. It addresses behaviors in domains directly related to environmental problems (e.g., mobility, energy and food consumption or waste disposal and recycling), as well as in a broad range of other societal relevant issues such as health care, respecting human rights, cultural tolerance, social justice, and prevention of crime. The broader concept of *sustainability literacy* [30-32], which covers a wide range of skills and attributes, therefore appears suitable to supplement the concept of environmental literacy in domains where aspects such as democracy, human rights, social justice, cultural diversity, individuality, and human health and well-being, are more salient than environmental problems.

Similar to environmental literacy, the goal of promoting sustainability literacy requires that sustainability oriented education and learning aims at cognitive as well as affective outcomes. Cognitive educational objectives include conveying a systemic understanding of the environment and environmental problems, including the role human activity plays in causing and ameliorating such problems [33]. This comprises an understanding of the structural social dilemmas and dynamics, which are often a crucial component of environmental problems [34,35]. Affective objectives include positive emotional bounds to nature and other human beings and pro-sustainability values, attitudes, and motivations [36,37].

2. Sustainability Learning: A Transdisciplinary and Multi-Level Concept

Acknowledging that education is an indispensable element for achieving sustainable development, the UN declared the period from 2005 to 2014 as a Decade of Education for Sustainable Development, aiming to provide an "opportunity for progressing towards implementing universal quality education that fosters the knowledge, skills, perspectives, and values that lead to a more sustainable future" ([38], p. 2).

Education for sustainable development includes formal, non-formal and informal learning, and currently there is a shift of emphasis from education to learning in education for sustainability [16,38]. Still, *sustainability learning* represents a much broader concept than sustainability education or education for sustainable development: Firstly, because learning processes aiming at sustainability are not confined to educational contexts; neither to formal nor to informal ones. Secondly, because mastering the challenges of sustainability depends on learning processes of individuals, as well as on learning processes of *human systems* at the level of groups, organizations, nations, supranational systems, and mankind as a whole [39-45].

People produce and constitute social systems and, at the same time, they are shaped and influenced by these systems [46-52]. Therefore, individual learning and uncoordinated actions of individuals are not sufficient for re-orienting human activities on local and global scales towards the principles of

sustainable development. *Collective agency* [48] involving socially coordinated and interdependent efforts, is required for promoting sustainability oriented behavioral, social, technological, and economic changes. Transformative organizational learning, as well as policy learning and societal learning on local and global levels, is needed for the development of values, laws and informal normative regulations that facilitate conditions and generate options for sustainable individual and collective behaviors [40]. Consequently, *sustainability learning* is best understood as a multi-level concept that comprises individual learning as well as group, organizational, and societal learning. Such a multi-level definition, which furthermore strongly emphasizes the role of transdisciplinarity, was formulated by Scholz *et al.* [43]:

> "Transdisciplinarity can be said to evolve from special types of problems, *i.e.*, real, complex, socially relevant problems, which ask for the integration of the knowledge of science and society [45,53,54]. Most of these problems are strongly related to sustainable development [55]. It can be said that planning and learning processes for sustainable development require transdisciplinarity as an approach [56]. This holds particularly true if the development and implementation of policies and mutual learning processes are targeted by the behaviour of individuals, industries, organizations, and governments. We refer to the corresponding process as 'sustainability learning'" ([43], p. 231).

Consistent with this perspective, *sustainability learning* is understood here as the learning of individuals and human systems such as groups, organizations, and human societies, which aims to achieve and facilitate sustainable development.

Learning on the level of groups has been addressed by social, group and organizational psychology, and involves processes of group development, role-taking, norm formation, collaborative learning, mutual learning, consensus building, and collective decision-making [57-60]. Learning on the levels of organizations, political entities, and society has been conceptualized by models of organizational and policy learning [39,61-64].

Baitsch, Jutzi, Delbruck, and Hasenbein [65] provided a consistent psychological conceptualization of individual, group, and organizational learning in terms of the development of the competencies of human systems. They understand competencies of a system as inner structural characteristics, which regulate and influence the system's visible actions. In order to resolve the problem of any group action being mediated by actions of individual group members, they assume actions, which represent an expression or product of group processes to be interpretable as group actions. On the level of organizations, they assume that actions of humans, which represent and fulfill their organizational role and function, are partly dissolved from these individuals and can be considered organizational actions.

A considerable body of scientific literature applies theories and concepts of group and organizational learning, societal learning, and policy learning in the context of promoting sustainability [39,41,66-72]. However, there are also many practical and scientific approaches that do not explicitly refer to the concept of learning, but involve what is understood here as sustainability learning. Theories of political, organizational, and cultural sciences often describe such processes as sustainability oriented innovation, management, development, transformation or change [17,44,73-78]. The orientation towards sustainability distinguishes sustainability learning from other individual, organizational, and societal learning and transformation processes. The multifaceted scientific

literature, which explicitly uses the term "sustainability learning," invariably shows this orientation [69,70,79-82]. For example, Tàbara and Pahl-Wostl [71] distinguish sustainability learning from social learning "as not all of the outcomes of social learning processes necessarily improve what we consider as essential for the long-term sustainability of social-ecological systems, namely, the co-adaptive systemic capacity of agents to anticipate and deal with the unintended, undesired, and irreversible negative effects of development" (p. 1). They conclude that the main difference between sustainability learning and social learning "is the content of what is learned and the criteria used to assess such content; these are necessarily related to increasing the capacity of agents to manage, in an integrative and organic way, the total social-ecological system of which they form a part" (p. 1).

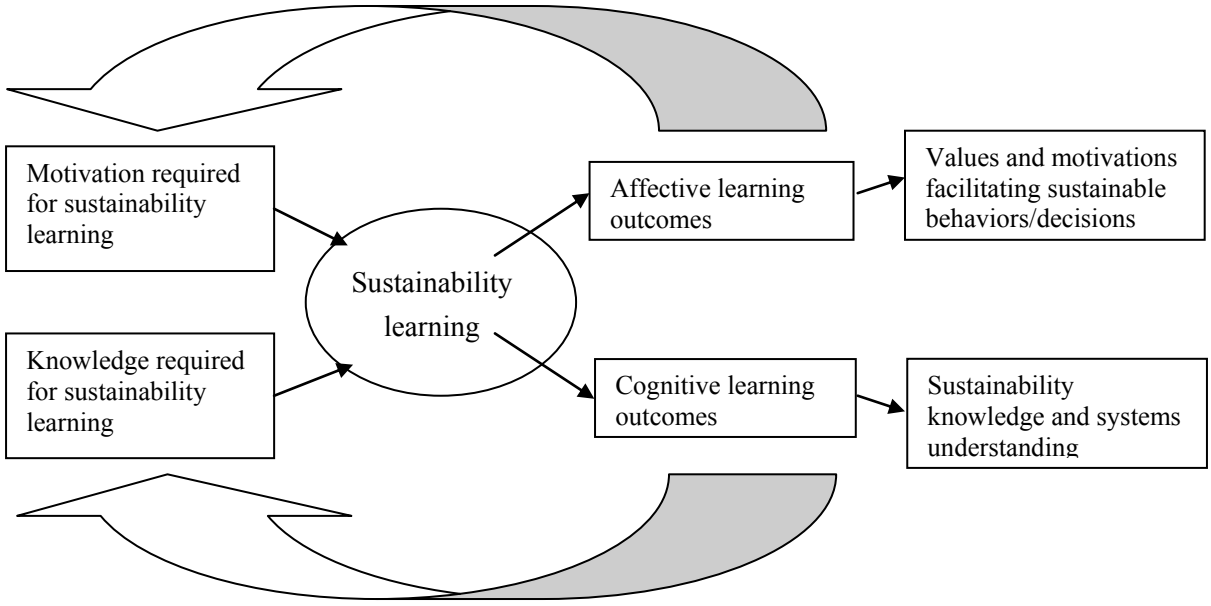
Sustainability learning in this sense can take many forms, and it can take place in different sectors and domains of society. Transdisciplinarity can be understood as a fundamental approach for involving science in sustainability learning. Transdisciplinary research transcends the boundaries of science in the sense that it involves equitable cooperation among different agents of society and academia with the aim to meet complex challenges of society [43,83]. In line with Agenda 21, calling for participation of all stakeholders and relevant experts in environmentally relevant problem-solving and decision-making processes, this view of transdisciplinarity acknowledges that scientific approaches need to cross the boundaries of science in order to serve sustainable development. According to Scholz [84], "transdisciplinarity aspires to make the change *from research for society to research with society*" (p. 13). Transdisciplinary research starts from relevant real-world problems and tackles them in processes of mutual learning between science and society, and with an orientation towards sustainability. "Through mutual learning, the knowledge of all participants is enhanced, including local knowledge, scientific knowledge, and the knowledge of concerned industries, businesses, and non-governmental organizations (NGO's). The sum of this knowledge will be greater than the knowledge of any single partner. In the process, the bias of each perspective will also be minimized" ([45], p. 7). Joint problem-solving, in which scientists from different disciplines collaborate with practitioners to solve real-world problems, goes beyond interdisciplinarity. It means opening the boundaries of science for non-scientists to mobilize previously unused potentials for tackling important societal problems and to facilitate innovative solutions. Such an understanding of transdisciplinarity is different from the perspective of Mittelstrass [85], who regards ideal interdisciplinary research, where scientists define and tackle problems independent of disciplinary scientific constraints, as transdisciplinary. Consistent with the aim of education for sustainable development to "equip all people, women and men, to be fully participating members of their own communities and also citizens of the world" ([38], p. 2), the mutual learning approach towards transdisciplinarity recognizes that non-academician lay people, who are confronted with and affected by environmental problems and decision-making are themselves experts (e.g., regarding their own life-world and culture). Transdisciplinarity requires open discovery and inquiry processes that involve discussion, negotiation and consensus building, and it needs to be based on an equitable partnership between people having different academic and non-academic backgrounds [54,84,86].

3. Motivations as Determinants and Outcomes of Sustainability Learning

From a system theory perspective, it is crucial to consider how outputs of processes influence the course of future processes. This relationship can range from reciprocal inhibitions through negative feedback to positive couplings, where outputs of a process strengthen the process, leading to increased outputs that further strengthen the process, and so on. Such positive feedback can be connected to vicious cycles destabilizing a system, but it can also serve as a momentum that allows for the encompassing transformation of a system to a new form of systemic organization, where re-occuring processes and the relationships between the elements of the system acquire new properties. It seems crucial to identify such positive couplings in the context of sustainability learning, since considerable momentum is required to achieve an encompassing reorientation of society towards principles of sustainability. Sustainability oriented motivation could play the role of an active mediator of such a momentum.

As is true for most psychological constructs, many definitions of the term *motivation* exist. However, it is commonly acknowledged that motivation can be understood as an internal state that arouses, directs, and sustains human behavior [87,88]. This also holds true for problem-solving and learning activities, and motivation therefore plays a fundamental role for learning as a prerequisite for the initiation and persistence of learning activities [89,90]. Motivation for sustainability learning is required for engaging in learning processes, and therefore, for achieving learning goals of both the cognitive and affective domain of Bloom's [21] taxonomy. Furthermore, it is important to consider that promoting the motivation to act in sustainable ways represents itself an affective learning goal of sustainability learning. Motivation hence plays a crucial role in sustainability learning as an antecedent and moderating variable influencing the learning process, and, at the same time, needs to be understood as an educational objective of sustainability learning. This implies that both the motivation to act in sustainable ways, as well as the motivation to participate in further activities of sustainability learning, are important affective learning goals (Figure 1).

Figure 1. Affective and cognitive learning outcomes serving as input variables for subsequent sustainability learning processes.



4. Motivation, Values and Human Needs

Sustainable development was defined by WCED [1] with reference to *human needs*, and therefore approaches linking motivation to needs are interesting in the present context.

Maslow [91] understands motivation as a process whereby individuals respond to needs by doing something about them. He assumes that humans are continuously motivated by needs. If a certain need is satisfied, the individual becomes motivated to satisfy other needs. His theory comprises a hierarchical model of needs which distinguishes between (i) physiological needs (e.g., food and water supply); (ii) needs for safety; (iii) social needs (e.g., for love and belongingness); (iv) esteem needs (e.g., for self-esteem and reputation); and (v) the need for self-actualization. In addition to these hierarchically ordered needs, he postulates needs for knowing and understanding, which are linked to curiosity and learning motivation. Maslow's overall theory was criticized for the presumption that needs of the lower levels of the supposed hierarchy must be satisfied before people become motivated to satisfy their higher order needs, and for the hereto connected differentiation between self-actualizing and non-self actualizing persons [92]. However, Maslow's classification of needs has been widely acknowledged, and has proven helpful for developing indicators of social well-being that cover important aspects of social sustainability [24,93,94].

The *Need-Press Model* by Murray [95] distinguishes primary needs, which have a direct biological basis (e.g., need for food, water, harm-avoidance) from secondary needs, which come from the biological ones (e.g., need for achievement, affiliation, autonomy, power, acquisition and exchange of information). According to the model, motivation depends on subjective factors, such as an individual's chronic need level, and the current level of satisfaction of different needs, as well as on characteristics of the social and physical environment, which refer to these needs (so-called *environmental press*, e.g., options for obtaining food and water; or options for meeting and getting to know other people), and the resulting motivation process drives and directs behavior [96,97].

In the Expectancy Theory of Motivation by Vroom [98], motivations are understood as a process governing choices among alternative forms of action. In Vroom's theory, an individual's motivation is assumed to depend on the (1) valence or affective orientation towards possible outcomes, (2) the expectancy or momentary belief concerning the likelihood that a particular act will have particular outcomes, and (3) the instrumentality of these initial outcomes for attaining second order outcomes that are ultimately desired. According to *Prospect Theory* by Kahneman and Tversky [99], the perceived probabilities of the possible consequences of an alternative decision influence choices via subjective *value functions*. They could show that when choosing among decision alternatives, people focus on the prospective gains or losses as compared to a subjective reference point considered to be neutral, and that they value gains and losses differently in the sense that they are reacting more sensitively to the latter [100]. The subjectively expected consequences of alternative paths of action, in combination with the subjective valuation of these consequences, play a central role in behavioral decision-making according to cognitive theories of motivation [87,88] and models of human behavior, such as the Theory of Planned Behavior or the Theory of Interpersonal Behavior [101-103]. The value system of a person thus serves as an important basis of motivation processes. However, in spite of the social and subjective nature of each person's values, these are determined to a large extent by cultural and biological factors related to rather universal human needs.

5. Intrinsic and Extrinsic Motivations in Different Contexts of Sustainability Learning

The conceptual differentiation between intrinsic and extrinsic motivation is crucial for understanding learning processes [104-106]: *Intrinsic* learning motivation can derive from curiosity and interest in the learning activity itself. It is linked to the joy felt when analyzing, inquiring, exercising, and solving problems. *Extrinsic* motivation for learning is linked to the outcomes of the learning activity as a means to certain ends. According to Ryan and Deci's [106] Self Determination Theory, autonomy, perceived competence and social relatedness, are human needs that can be regarded as three key factors for the development of intrinsic learning motivation. These factors are strongly influenced by the social context of learning, and social processes therefore play an important role in facilitating intrinsic learning motivation. Furthermore, the Self Determination Theory holds that extrinsic motivation is not necessarily non-autonomous. Instead, it can vary greatly in autonomy, with self-regulation taking forms ranging from external, introjected, and identified regulation to fully integrated regulation. Externally regulated motivation is the least autonomous. It means that a certain (learning) behavior is performed to satisfy external demands, and that the "self" is ultimately not regarded as intending and causing this behavior. In regulation through identification, learners are externally motivated by conscious personal goals (e.g., learning in order to achieve a professional career). Finally, in integrated regulation, extrinsic motivation is assimilated to the self and is fully congruent with a person's values and needs.

Sustainability learning in different contexts profits differently from intrinsic and extrinsic motivations. For example, students pursuing a university degree in sustainability sciences might be motivated by the desire for a successful professional or research career. Such ambitions are linked to positive extrinsic motivations having to do with professional success (e.g., monetary rewards and professional status). Moreover, professional activities form an important part of a person's identity. Professional norms can thus become tied to graduates' self-concept, which enables them to regulate extrinsic, profession-based motivations autonomously [106]. Compared to university education, career related motivations appear less important for learners in basic sustainability education or for the average recipients of public sustainability campaigns. In addition, those taking part in a university sustainability program are presumably better educated and informed on the importance of sustainable development as compared to pupils or "average" recipients of environmental campaigns. Acknowledging these considerations can help us understand why the enthusiasm of lay people regarding the ideas of sustainability is not always high. As a consequence, it is very important to promote the motivation of lay people for sustainability learning. Enhancing intrinsic motivations for taking part in sustainability learning activities seems particularly important, because such motivations might also support the development of pro-sustainability motivations for changing behavioral patterns in everyday life. Extrinsic incentives for learning can in some cases reduce a learner's intrinsic learning motivation [107]. Hence, there could be a lack of transfer into everyday life if taking part in sustainability education when learning is purely externally motivated (e.g., by grades in school; by incentives used in campaigns or policy measures).

Factors such as perceived competence and autonomy of the learners, social relatedness of the learning process, holistic learning tasks, and allowing learners to participate actively, are factors that can promote intrinsic motivation and positive attitudes towards learning [105,106]. However,

traditional teaching methods used in school do sometimes hinder pupil's active participation, autonomy, and motivation [89]. In school, learning goals are usually defined by the teachers and school administration. Goals of public sustainability campaigns are usually also pre-defined by the institutions offering these activities. Thus, the lack of learner's autonomy could even aggravate motivation problems in sustainability education in schools and when considering recipients of sustainability communication or environmental campaigns. Kyburz-Graber *et al.* [108] emphasize the importance of developing a participatory relationship between learners and teachers in contexts of sustainability learning. School teachers should discuss learning goals and plan sustainability oriented instruction together with the learners. This allows the learners to co-define and influence the topics of the instruction, and creates room for creativity and autonomous engagement of the learners. A participatory culture, involving all groups and stakeholders in decision-making processes, is itself a core idea of sustainability [109]. It is therefore important for sustainability learning to engage learners in constructive planning activities and to let them take responsibility for their own activities.

Project-based learning activities have the potential to promote intrinsic learning motivations because they involve active participation and personal experiences, and make the learners interested in the development and outcomes of the projects. Outdoor environmental education allows the learners to experience nature, strengthens their emotional bonds with nature, and enhances their awareness and concern for environmental problems [110,111]. Project-based outdoor education in natural settings can have positive effects on learning motivation and improves environmental awareness. Consequently, environmental education frequently involves field trips and project-like activities that are connected to direct encounters with nature [37,108,112].

Nevertheless, sustainability communication and education also occurs via the mass media, for example, through television broadcasts [113]. Media play an important role in raising public awareness for sustainable development. To achieve this aim, media reporting needs to present complex sustainability problems in an accessible and interesting way that elicits experiential modes of thinking [114]. To only provide factual scientific information in terms of numbers and abstract models is not an effective way to promote pro-sustainability motivations and behavior changes, because such information elicits analytic modes of thinking, and is thus not processed emotionally [115]. Simulation and gaming is an example of a didactical approach towards sustainability education (and communication), which often involves modern media, and promotes active participation, problem-based learning, and personal experience [116-119]. According to Torres and Macedo [120], using simulation and gaming methods in sustainability education can "make the overall experience more enjoyable and therefore increase receptivity to the ideas presented" (p. 119).

Approaches also exist that aim to promote active participation and personal experience of citizens in sustainability campaigns, for example, through involving the population in personal communications, and cultural or project-like activities (e.g., clean-up days, topic related theatre or music performances). As far as sustainability education at the university level is concerned, *Transdisciplinary Case Studies* [121,122] are an example of an instructional format involving project-based learning. According to Scholz *et al*. [43]: "transdisciplinary case studies (TCS) are a powerful tool for teaching and research on complex environmental problems to conduct individual, organizational, and societal sustainability learning" (pp. 227-228). In TCS, complex societal and ecologically relevant sustainability problems are addressed through a transdisciplinary mutual learning

approach [84,123,124]. Students take part in a research process, where they cooperate with university teachers and external stakeholders, including persons from the affected population. Thus, a real-world problem, which drives students' learning activities, is investigated with the aim of identifying options for sustainable transformations, and at the same time sustainability relevant key competencies are imparted to students. Here, university students become particularly intrinsically motivated, if they take case or problem ownership [43,60]. Such intrinsic motivation can support the analysis and identification of sustainable options and strategies in a transdisciplinary process. Moreover, when sustainable options and strategies have been identified, intrinsic motivations connected to problem-ownership can also support the implementation of sustainable options that have been identified.

6. Cooperative Motivation as a Precondition and Goal of Sustainability Learning

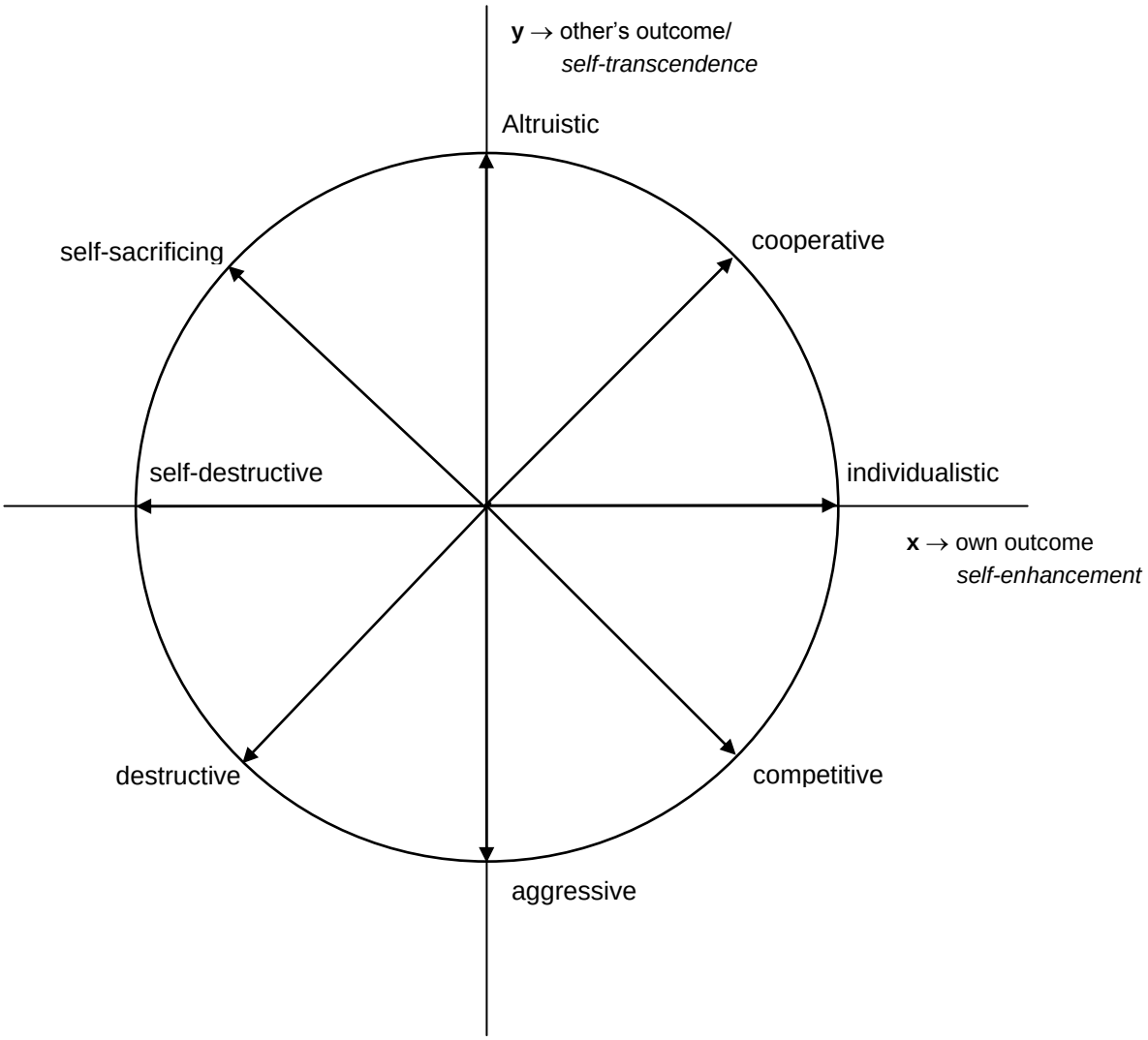
Single individuals are not capable of achieving the required encompassing societal transformations towards sustainability, local, regional, and global partnerships, alliances, networks, groups, *etc.* need to be formed in order to bring forward the sustainability agenda. Cooperation in coalitions and networks results in synergies that are needed to achieve the critical mass of knowledge and power that is necessary for proceeding effectively in projects and issues related to sustainability [73,118,125,126]. Motivations for cooperating with each other are a prerequisite for the formation of partnerships, networks, coalitions, and organizations. Engaging in cooperative activities is connected to processes of mutual learning, and is intended to support sustainability oriented projects and activities, and hence to promote sustainable development. In addition, the motivation to continue to cooperate, and to eventually even intensify the cooperation in the future, is a further important outcome of cooperative activities, and needs to be considered. Therefore sustainability learning activities should proceed in ways which increase cooperative motivations.

The crucial role cooperation plays in sustainable development has been investigated in depth by research on *social dilemmas* [35,40,127-130]. These dilemmas involve conflicts between public interest, in terms of (long-term) benefits of a large number of persons, and the self-interest of single individuals. The achievement of sustainable development is often hindered by such conflicts. For example, there can be conflicts between the aim to preserve the environment and its resources (e.g., forest cover, fish stocks, water supplies) and the economic interests of stakeholders aiming to exploit these resources. The dilemma in such situations is typically that each individual stakeholder is better off when exploiting a public environmental resource as much as possible as long as the other stakeholders restrain themselves. However, when all stakeholders follow the strategy of maximally exploiting the environmental resource, then harvest or usage rates surmount recovery rates, and the environmental resource becomes depleted and all stakeholders suffer greatly. It therefore appears individually rational for each stakeholder to exploit the environment, but collectively it is rational for the stakeholders to act modestly in such a situation.

For the analysis of decision-making in social dilemma situations, a theoretically oriented social psychological model has been developed, which distinguishes between different motivational orientations ranging from aggression and competition over individualism, to altruism and cooperation [129,131,132]. A corresponding circle of motivational orientations is presented in Figure 2. Accordingly, *individualistically motivated* people (or agents such as organizations or nations)

pursue their own interests without considering the outcomes of others. Those having *cooperative* motivations pursue their own interests, but consider positive outcomes of others to be important. *Altruistic* motivations are understood as aiming to help others without serving their own interests, whereas persons with a *competitive* social motivation are concerned with having better outcomes than others. In principle, the latter implies a preference for negative outcomes of others, since this promotes a positive discrepancy between own outcomes and those of others. *Aggressive* motivations elicit behaviors that clearly aim to harm others.

Figure 2. Circle of the social orientation of motivations in situations involving conflicting interests, adapted from similar circles [131-133]. x = outcome aspired for oneself (respectively for the own group, organization, human system) ranging from positive (individualistic self-enhancement) over indifferent/not focused (altruism, aggression) to negative (self-destructive). y = outcome aspired for another person (respectively for another group, organization, human system or for a certain environmental system) ranging from positive (altruism) over indifference to negative (aggression).



In social dilemma situations, cooperative motivational orientations and decisions of the involved agents are crucial to overcome the dilemma, and hence, to preserve environmental resources for

enduring usage [128,129]. These findings are not restricted to typical social dilemmas used in psychological laboratory studies. Environmentally positive behaviors in diverse domains have been conceptualized and understood as cooperative, self-transcending, pro-social, or altruistic behavior [130,134-138]. Self-transcending, altruistic orientations have been further differentiated into anthropocentric value orientations and humanistic altruism on the one hand, and ecocentric value orientations and biospheric altruism on the other [139-143]. Both types of self-transcendent value orientations tend to be positively correlated with each other as well as with pro-environmental behaviors in various domains, and, ,as one might expect, some studies have shown ecocentrism to be a stronger predictor of pro-environmental behaviors than anthropocentrism [130,144,145]. The circle of Figure 2 can depict ecocentric value perspectives of an individual or human system *x*, if *y* represents an environmental system (instead of a human system). The mutual motivational orientations between individuals and human systems, such as groups and organizations which are (considered to be) important in the context of a certain sustainability issue, can thus be depicted using the circumplex model, as well as the motivational orientations that these individuals and human systems have regarding diverse environmental systems.

The prototypical motivational orientations of aggression and competition as depicted in Figure 2 are not oriented towards sustainable ends, insofar as they aim at negative outcomes of others, and hence, aim at reducing the possibilities of others for meeting their needs. Notably, competitive aims (e.g., in terms of outperforming others) do not necessarily require strategies aiming at negative outcomes of others as depicted in Figure 2. Instead, competitive advantages can also be achieved by individualistic strategies focusing exclusively on own outcomes, and even by rather cooperative competition strategies that promote own outcomes somewhat more strongly than those of others. However, aggression and negative forms of competition can obviously pose serious threats to sustainable development. For example, competition between ethnic groups and nations regarding access to scarce resources such as oil or water can lead to aggression and military conflicts that deteriorate sustainable development.

As is true for socially positive motivational orientations such as altruism and cooperation, motivational orientations of competition and aggression form part of the innate biological constitution of humans, and show historical and cross-cultural stability [146-150]. However, cultural surroundings, social norms, laws, and education and learning can influence human values, and orientate motivational forces towards positive developmental ends. According to Bandura [151], innate behavioral tendencies facilitating aggression towards other people can be overcome if cultural surroundings and social structures facilitate this. People have the possibility to exert moral agency in line with their personal standards if societal surroundings convey corresponding norms and prevent individuals from disengaging from these norms. In such surroundings, self-regulatory mechanisms can provide people with the power to autonomously *refrain from behaving inhumanely* and to *proactively behave humanely* corresponding to the *dual nature of moral agency* described by Bandura *et al.* [152].

Sustainability learning entails promoting cooperation between humans, and promoting a mutually beneficial co-evolution between human and environmental systems. Consensus building and mutual learning in groups represents an effective means for dealing with conflicting interests in a cooperative way, and with an orientation towards sustainability. For facilitating cooperation within groups, it is crucial to achieve and maintain positive intra-group relationships. Social inclusion and equality of all

group members, and group members displaying mutual appreciation and respect for each other, are crucial aspects required to support positive intra-group relationships, and hence to promote constructive communication and cooperation required to solve social dilemmas [153].

However, these considerations are not confined to the roles group members take in specific group interaction and discussion processes. In order to effectively promote cooperative motivations, social fairness is also needed in the wider frame of society in which collective sustainability learning and group interaction processes are embedded. According to psychological exchange theories, social and economic injustice can substantially reduce cooperative motivations [154]. Consistent with this, Lemert [155] argues that the poor can hardly be expected to cooperate with the powerful and better off as long as no tendency towards a reduction of severe inequalities is perceivable. Therefore, a societal process leading to greater economic and social justice represents a precondition for eliciting in all people the cooperative motivations that are important for sustainability learning in any context, and hence also for engaging them in pro-environmental, sustainability oriented behaviors.

7. The Ongoing Inquiry on Sustainability as a Sustainability Learning Process

Conceptualizations of sustainability provide the frame for sustainability learning, problem-solving, and decision-making in all contexts, and therefore merit serious attention. The scientific use of the term *sustainable development* can be traced back to the 18th century, when Von Carlowitz [156] outlined principles for the enduring usage of forests. His major management guideline was to not cut down more trees than can grow in a certain period of time in order to obtain enduring yields. This reflects a general principle of the sustainable use of renewable resources, namely that harvest rates should not exceed regeneration rates. Furthermore, the early work of Von Carlowitz acknowledges the essential meaning of responsible resource management for enduring wealth of society and the environment. The meaning of the term *sustainability* has changed since then as new core ideas have been incorporated [43]. Similar to Von Carlowitz, WCED [1] emphasizes that sustainability aims at protecting the environment and its resources as well as at providing social and economic welfare to present and subsequent generations. In addition, WCED understands sustainable development as one that is socially just, and ethically acceptable, and that aims at technological and economic development as well as at the preservation of environmental, social and cultural values. Accordingly, sustainability is a conservative principle and at the same time, a principle of change management and technical and cultural innovation and transformation. It comprises an ethical relationship of the present with past and future generations, which requires the maintenance of human-environment systems within functional limits, and a well-adjusted balance between stability and change [72,121,157].

Sustainability is increasingly acknowledged and accepted as a crucial normative regulation principle of society and represents at the same time a dynamic quality of human-environment systems [43]. As a normative and systemic concept, sustainability has moral and political implications that take the complexity and interrelatedness of local, regional, and global socio-economic and environmental processes into account. Questions concerning social justice that were formerly discussed primarily in terms of socio-economic ethics based on religious, philosophic or economic beliefs are now comprised in the wider societal discussion on sustainability.

As a general normative regulation principle for society, sustainability entails so many facets and aspects that consensus on its precise meaning can hardly be expected [158]. Controversies on the symbolic, descriptive, and normative meaning and practical implications of the term *sustainability* have been, and are still, ongoing [159,160]. Researchers from different scientific disciplines and even within one discipline often vary in their interpretation and use of the term, and they also emphasize and promote different strategies for achieving it. The Brundtland Report already anticipated these controversies when stating that "interpretations will vary, but must share certain general features and must flow from a consensus on the basic concept of sustainable development and on a broad strategic framework for achieving it" ([1], Chapter 2.1). This statement is consistent with Jacobs [109], who postulated that sustainability represents a *contestable concept*, and as such possesses complexity, normative implications and two levels of "meaning": A first level of meaning defined by core value related ideas, and a second level referring to how the concept should be interpreted in practice. However, it seems that significant parts of the scientific and political struggles over sustainability do, in fact, touch upon core ideas of sustainability. Controversies between proponents of *weak* and *strong sustainability* [161-163] and between *anthropocentric* and *ecocentric* perspectives [145] are prominent examples.

Such fundamental controversies cast doubts on the view of Jacobs [109] that the first level of the meaning of the contested concept of sustainability is unalterable as "the core ideas are fixed and cannot now be changed through rational argument" (p. 24). Instead, it seems possible that quite paradigmatic shifts in the conceptualization of sustainability will occur in the future as technological, environmental, economic, and socio-cultural changes to a large extent are taking place on a global scale and with rapid speed. Changes in the environment and within human systems can substantially alter the paths of action that are necessary to achieve sustainable development. The further development of mainstream concepts of sustainability is neither predictable, nor is it a process of intrinsic societal self-organization. Particularly when environmental conditions change dynamically and substantially, the differences between self-organizing actions on the part of human systems, and the effects of external perturbances on the organization of these systems, are hardly discernable [164]. Instead, a concomitant development of human-environment systems and human's conception of what is sustainable takes place.

From a constructivist perspective, the meaning of sustainability is continuously negotiated by the contributors to a *societal discourse*, where cyclic interdependencies exist between the individual contributions constituting the discourse, and the discourse forming the basis for understanding each contribution [165]. A dynamic understanding of sustainability is consistent with the view of Laws *et al.* [157] that sustainable development requires a continuous scientific and societal process of critical thinking, observation, discourse, and analysis, which involves both practical and conceptual challenges. According to Laws *et al.* sustainable development is "a process of learning in which action is shaped by goals and goals are revised in the light of experience" (pp. 252-253).

Acknowledging that contemporary concepts of sustainability are to some extent disputed, fuzzy, and provisional, needs not discourage the use of the concept. The vagueness and the individualistic, multifaceted, but at the same time social and consensual nature of the sustainability concept can generate motivation for sustainable development. Boons and Roome [166] accordingly state that: "the concept of sustainable development [...] appeals to many people precisely because the 'openness' of

the definition enables people to construct and contribute to the process of defining what sustainable development entails. This is its most important feature, because it enables actors who wish to work on the goal and process of sustainable development to be involved in a discussion of what the concept means to the parties involved" (p. 53).

The ongoing, multilayered (e.g., scientific, cultural, social, societal, organizational, individual) inquiries and discourses, which strive for an understanding of what sustainability ultimately means (for the scientific community, for a given cultural or political entity or organization, or for a particular individual person) are understood here to be sustainability learning processes of overriding importance, since they aim at formulating (provisional) super-ordinate goals that orientate sustainability learning processes in manifold other contexts. These inquiry processes should not be understood as temporally confined and intended to arrive at the one correct understanding of sustainability. The views of how nature is to be understood, valued, and acted upon are socially constructed, and therefore culturally variable [167]. Hence, temporal, cultural, and spatial variation is to be appreciated as the natural outcome of an open and constructive learning process where no one culture or generation unilaterally imposes their own understanding of sustainability on others.

The first principle of the Rio declaration [3] requires that "human beings are at the centre of concerns for sustainable development." Contrary to this principle, many contemporary attempts towards defining sustainability barely consider cultural diversity and individual human beings. For example, economic approaches have a tendency to define sustainability in ubiquitous terms, and to use formulations that appear qualified for entertaining doubts as to whether economies serve humans or *vice versa*. Such approaches can be helpful for understanding certain important aspects of sustainability. However, they are barely suitable for inspiring unique people, having diverse cultural backgrounds, for the ideas of sustainability. Psychological principles of reciprocity suggest that people will be more interested in sustainability concepts that focus on them, as compared to abstract concepts that ignore their individuality. Since psychology has *per se* a focus on human individuals, psychologically oriented approaches towards defining sustainability could be well suited to inspire people for the ideas of sustainability. A major contribution of psychology for an appropriate conceptualization and understanding of sustainability could be to increase emphasis on cultural diversity and on the well-being and quality of life of *unique individuals*, and to clarify that economic activities need to be evaluated with reference to the satisfaction of human needs, and should not be regarded as ultimate goals. From a psychological perspective, meeting the needs of people means improving their social inclusion, well-being, happiness, and quality of life, and it therefore appears crucial for promoting and analyzing sustainable development to formulate corresponding goals and indicators [93,168]. To complement goals of environmental and economic sustainability with the formulation of psychological, individual centered goals, such as sustaining and increasing the well-being and quality of life of unique individuals, may prove helpful in better motivating people for sustainability learning.

References

1. World Commission on Environment and Development. *Our Common Future (Brundtland Report)*; Oxford University Press: Oxford, UK, 1987.
2. *UN General Assembly Resolution 42/187. Report of the World Commission on Environment*; United Nations: New York, NY, USA, 1987.
3. *Report of the United Nations Conference on Environment and Development, 3–14 June 1992, (A/CONF. 151/26). Annex I. Rio Declaration on Environment and Development*; United Nations: New York, NY, USA, 1992.
4. *World Summit on Sustainable Development, Johannesburg Declaration on Sustainable Development. A/CONF.199/20*; United Nations: New York, NY, USA, 2002.
5. Kates, R.W.; Clark, W.C.; Corell, R.; Hall, J.M.; Jaeger, C.C.; Lowe, I.; McCarthy, J.J.; Schellnhuber, H.J.; Bolin, B.; Dickson, N.M.; *et al.* Sustainability science. *Science* **2001**, *292*, 641–642.
6. Ashford, N.A. Major challenges to engineering education for sustainable development: What has to change to make it creative, effective, and acceptable to the established disciplines? *Int. J. Sustain. High. Educ.* **2004**, *5*, 239–250.
7. Boks, C.; Diehl, J.C. Integration of sustainability in regular courses: Experiences in industrial design engineering. *J. Clean. Prod.* **2006**, *14*, 932–939.
8. Kamp, L. Engineering education in sustainable development at Delft University of Technology. *J. Clean. Prod.* **2006**, *14*, 928–931.
9. Stubbs, W.; Cocklin, C. Teaching sustainability to business students: Shifting mindsets. *Int. J. Sustain. High. Educ.* **2008**, *9*, 206–221.
10. Division of Early Warning and Assessment, UNEP. *GEO-3 /Global Environment Outlook 3. Past, Present and Future Perspectives*; Earthscan Publications: London, UK, 2002.
11. IPCC. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, 2007.
12. Stern, N.; Peters, S.; Bakhshi, V.; Bowen, A.; Cameron, C.; Catovsky, S.; Crane, D.; Cruickshank, S.; Dietz, S.; Edmonson, N.; *et al. Stern Review: The Economics of Climate Change*; HM Treasury: London, UK, 2006.
13. Aldhous, P. The world's forgotten crisis—Over a billion people cannot get clean water, and things are getting worse. *Nature* **2003**, *422*, 251–253.
14. Christensen, J.H.; Christensen, O.B. Severe summertime flooding in Europe. Even as summers become drier, the incidence of severe precipitation could increase. *Nature* **2003**, *421*, 805–806.
15. *Agenda 21: Earth Summit—The United Nations Programme of Action from Rio de Janeiro*; United Nations: New York, NY, USA, 1992.
16. *Education for Sustainability, from Rio to Johannesburg: Lessons Learnt from a Decade of Commitment*; UNESCO: Paris, France, 2002.
17. Nazaretyan, A.P. Power and wisdom: Toward a history of social behavior. *J. Theor. Soc. Behav.* **2003**, *33*, 405–425.

18. Scholz, R.W.; Wiek, A. Operational eco-efficiency: Comparing firms' environmental investments in different domains of operation. *J. Ind. Ecol.* **2005**, *9*, 155–170.
19. Princen, T. Principles for sustainability: From cooperation and efficiency to sufficiency. *Glob. Environ. Polit.* **2003**, *3*, 33–50.
20. Mauch, U.; North, N.; Pulli, R. Between efficiency and sufficiency. The optimal combination of policy instruments in the mobility sector towards sustainable development. In *Changing Things—Moving People*; Kaufmann-Hayoz, R., Gutscher, H., Eds.; Birkhäuser: Basel, Switzerland, 2001; pp. 133–150.
21. Bloom, B.S. *Taxonomy of Educational Objectives—The Classification of Educational Goals*; David McKay: New York, NY, USA, 1956.
22. Shephard, K. Higher education for sustainability: Seeking affective learning outcomes. *Int. J. Sustain. High. Educ.* **2008**, *9*, 87–98.
23. Sipos, Y.; Battisti, B.; Grimm, K. Achieving transformative sustainability learning: Engaging head, hands and heart. *Int. J. Sustain. High. Educ.* **2008**, *9*, 68–86.
24. *An Introductory Course for Policymakers and Practitioners of Education Programmes. Quality Education in Conflict-Affected Countries. Translating the Vision of Quality Education into the Practical Work of Reconstruction. Facilitator's Manual*; UNESCO: Paris, France, 2006.
25. Hsu, S.J.; Roth, R.E. An assessment of environmental literacy and analysis of predictors of responsible environmental behaviour held by secondary teachers in the Hualien area of Taiwan. *Env. Educ. Res.* **1998**, *4*, 229–249.
26. Moody, G.L.; Hartel, P.G. Evaluating an environmental literacy requirement chosen as a method to produce environmentally literate university students. *Int. J. Sustain. High. Educ.* **2007**, *8*, 355–370.
27. Scholz, R.W. *Environmental Literacy in Science and Society: From Knowledge to Decisions*; Cambridge University Press: Cambridge, UK, in press.
28. Hart, P.; Nolan, K. A critical analysis of research in environmental education. *Stud. Sci. Educ.* **1999**, *34*, 1–69.
29. Rickinson, M. Learners and learning in environmental education: A critical review of the evidence. *Env. Educ. Res.* **2001**, *7*, 207–317.
30. Colucci-Gray, L.; Camino, E., Barbiero, G.; Gray, D. From scientific literacy to sustainability literacy: An ecological framework for education. *Sci. Educ.* **2006**, *90*, 227–252.
31. Murray, P.E.; Cotgrave, A.J. Sustainability literacy: The future paradigm for construction education? *Struct. Surv.* **2007**, *25*, 7–23.
32. *The Handbook of Sustainability Literacy: Skills for a Changing World*; Stibbe, A., Ed.; Green Books: Dartington, CA, USA, 2009.
33. Gambro, J.S.; Switzky, H.N. A national survey of high school students' environmental knowledge. *J. Environ. Educ.* **1996**, *27*, 28–33.
34. Cross, J.G.; Guyer, M.J. *Social Traps*; University of Michigan Press: Ann Arbor, MI, USA, 1980.
35. Hardin, G. The tragedy of the commons. *Science* **1968**, *162*, 1243–1248.
36. *Changing Things—Moving People*; Kaufmann-Hayoz, R., Gutscher, H., Eds.; Birkhäuser: Basel, Switzerland, 2001.

37. Kyburz-Graber, R.; Schlüter, K. *Umweltbildung im 20. Jahrhundert: Anfänge, Gegenwartsprobleme, Perspektiven*; Waxmann: Münster, Germany, 2001.
38. *Contributing to a More Sustainable Future: Quality Education, Life Skills, and Education for Sustainable Development*; UNESCO: Paris, France, 2005.
39. Bulkeley, H. Urban sustainability: Learning from best practice? *Environ. Plann. A* **2006**, *38*, 1029–1044.
40. Dietz, T.; Ostrom, E.; Stern, P.C. The struggle to govern the commons. *Science* **2003**, *302*, 1907–1912.
41. Gudz, N.A. Implementing the sustainable development policy at the University of British Columbia: An analysis of the implications for organisational learning. *Int. J. Sustain. High. Educ.* **2004**, *5*, 156–168.
42. Scholz, R.W.; Binder, C. Principles of Human-Environment Systems (HES) research. In *Complexity and Integrated Resources Management, Transactions of the 2nd Biennial Meeting of the International Environmental Modelling and Software Society*; Pahl, C., Schmidt, S., Rizzoli, A.E., Jakeman, T., Eds.; International Environmental Modelling and Software Society: Manno, Switzerland, 2004; pp. 791–796.
43. Scholz, R.W.; Lang, D.J.; Wiek, A.; Walter, A.I.; Stauffacher, M. Transdisciplinary case studies as a means of sustainability learning: Historical framework and theory. *Int. J. Sustain. High. Educ.* **2006**, *7*, 226–251.
44. Starik, M.; Rands, G.P. Weaving an integrated web: Multilevel and multisystem perspectives of ecologically sustainable organizations. *Acad. Manage. Rev.* **1995**, *20*, 908–935.
45. *Transdisciplinarity: Joint Problem Solving Among Science, Technology, and Society. An Effective Way for Managing Complexity*; Thompson, K.J., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R.W., Welti, M., Eds.; Birkhäuser: Basel, Switzerland, 2001.
46. Asch, S.E. Studies of independence and conformity: A minority of one against a unanimous majority. *Psychol. Monogr.* **1956**, *70*, 177–190.
47. Bandura, A. *Social Foundations of Thought and Action: A Social-cognitive Theory*; Prentice-Hall: Upper Saddle River, NJ, USA, 1986.
48. Bandura, A. Social cognitive theory: An agentic perspective. *Annu. Rev. Psychol.* **2001**, *52*, 1–26.
49. Bronfenbrenner, U. Toward an experimental ecology of human development. *Am. Psychol.* **1977**, *32*, 513–531.
50. Janis, I.L. *Victims of Groupthink, a Psychological Study of Foreign-Policy Decisions and Fiascoes*; Houghton Mifflin Company: Boston, MA, USA, 1972.
51. Janis, I.L. Groupthink. In *Leadership: Understanding the Dynamics of Power and Influence in Organizations*; Vecchio, R.P., Ed.; University of Notre Dame Press: Notre Dame, MA, USA, 1997; pp. 163–176.
52. Milgram, S. *The Individual in a Social World*; Addison-Wesley: Reading, MA, USA, 1977.
53. Burger, P.; Kamber, R. Cognitive integration in transdisciplinary science: Knowledge as a key notion. *Issues Integr. Stud.* **2003**, *21*, 43–73.

54. Scholz, R.W.; Mieg, H.A.; Oswald, J.E. Transdisciplinarity in groundwater management: Towards mutual learning of science and society. *Water Air Soil Poll.* **2000**, *123*, 477–487
55. Bl ättel-Mink, B.; Kastenholz, H. Transdisciplinarity in sustainability research: Diffusion conditions of an institutional innovation. *Int. J. Sust. Dev. World* **2005**, *12*, 1–12.
56. Meppem, T.; Gill, R. Planning for sustainability as a learning concept. *Ecol. Econ.* **1998**, *26*, 121–137.
57. Baron, R.S.; Kerr, N.L. *Group Process, Group Decision, Group Action*, 2nd ed.; Open University Press: Buckingham, UK, 2003.
58. Hansmann, R.; Mieg, H.A.; Scholz, R.W.; Crott, H.W. Shifting Students' to Experts' complex systems knowledge: Effects of bootstrapping, group discussion, and case study participation. *Int. J. Sustain. High. Educ.* **2003**, *4*, 151–168.
59. McGrath, J.E. *Groups: Interaction and Performance*; Prentice-Hall: Upper Saddle River, NJ, USA, 1984.
60. Stauffacher, M.; Walter, A.; Lang, D.; Wiek, A.; Scholz, R.W. Learning to research environmental problems from a functional social-cultural constructivism perspective: The transdisciplinary case study approach. *Int. J. Sustain. High. Educ.* **2006**, *7*, 252–275.
61. Argyris, C. *Wissen in Aktion. Eine Fallstudie zur lernenden Organisation*; Klett-Cotta: Stuttgart, Germany, 1997.
62. Argyris, C.; Sch ön, D. *Organizational Learning—A Theory of Action Perspective*; Addison-Wesley: Reading, MA, USA, 1978.
63. Huber, G. Organizational learning: The contributing processes and the literatures. *Organ. Sci.* **1991**, *2*, 88–115.
64. Senge, P. *The Fifth Discipline: The Art and Practice of the Learning Organization*; Doubleday: New York, NY, USA, 1990.
65. Baitsch, C.; Jutzi, K.; Delbruck, I.; Hasenbein, U. Organisationales Lernen: eine organisationspsychologische Konzipierung der Entwicklung von Kompetenz bei Individuen, Gruppen und Organisationen. In *Organisationslernen im Interdisziplin ären Dialog*; Gei ßler, H., Lehnhoff, A., Petersen, J., Eds.; Deutscher Studien Verlag: Weinheim, Germany, 1998; pp. 91–108.
66. Adomssent, M.; Godemann J.; Michelsen, G. Transferability of approaches to sustainable development at universities as a challenge. *Int. J. Sustain. High. Educ.* **2007**, *8*, 385–402.
67. Albrecht, P.; Burandt, S.; Schaltegger, S. Do sustainability projects stimulate organizational learning in universities? *Int. J. Sustain. High. Educ.* **2007**, *8*, 403–415.
68. Clarke, S.; Roome, N.J. Sustainable business: Learning—action networks as organizational assets. *Bus. Strateg. Environ.* **1999**, *8*, 296–310.
69. Fenwick, T. Developing organizational practices of ecological sustainability: A learning perspective. *Leadersh. Organ. Dev. J.* **2007**, *28*, 632–645.
70. Ryan, P. Sustainability partnership: Eco-strategy theory in practice? *Manag. Environ. Qual. Int. J.* **2003**, *14*, 256–278.

71. Tàbara, J.D.; Pahl-Wostl, C. Sustainability learning in natural resource use and management. *Ecol. Soc.* **2007**, *12*, article 3. Available online: http://www.ecologyandsociety.org/vol12/iss2/art3/ (accessed on 20 August 2009).
72. Walker, B.; Carpenter, S.; Anderies, J.; Abel, N.; Cumming, G.S.; Janssen, M.; Lebel, L.; Norberg, J.; Peterson, G.D.; Pritchard, R. Resilience management in social-ecological systems: A working hypothesis for a participatory approach. *Conserv. Ecol.* **2002**, *6*, 320–333.
73. Davos, C.A. Sustaining co-operation for coastal sustainability. *J. Environ. Manage.* **1998**, *52*, 379–387.
74. Gladwin, T.N.; Kennelly, J.J.; Krause, T.S. Shifting paradigms for sustainable development: Implications for management theory and research. *Acad. Manage. Rev.* **1995**, *20*, 874–907.
75. L'Etang, J. Ethical corporate social responsibility: A framework for managers. *J. Bus. Ethics* **1995**, *14*, 125–132.
76. Richardson, G.R.A.; Lynes, J.K. Institutional motivations and barriers to the construction of green buildings on campus: A case study of the University of Waterloo, Ontario. *Int. J. Sustain. High. Educ.* **2007**, *8*, 339–354.
77. Shrivastava, P. The role of corporations in achieving ecological sustainability. *Acad. Manage. Rev.* **1995**, *20*, 936–960.
78. Velazquez, L.; Munguia, N.; Platt, A.; Taddei, J. Sustainable University: What can be the matter? *J. Clean. Prod.* **2006**, *14*, 810–819.
79. Beringer, A. The Lüneburg sustainable university project in international comparison: An assessment against North American peers. *Int. J. Sustain. High. Educ.* **2007**, *8*, 446–461.
80. Maiteny, P.T. Mind in the gap: Summary of research exploring 'inner' influences on pro-sustainability learning and behaviour. *Env. Educ. Res.* **2002**, *8*, 299–306.
81. Pearson, S.; Honeywood, S.; O'Toole, M. Not yet learning for sustainability: The challenge of environmental education in a university. *Int. Res. Geogr. Environ. Educ.* **2005**, *14*, 14–27.
82. Perdan, S.; Azapagic, A.; Clift, R. Teaching sustainable development to engineering students. *Int. J. Sustain. High. Educ.* **2000**, *1*, 267–279.
83. Scholz, R.W.; Marks, D. Learning about transdisciplinarity: Where are we? Where have we been? Where should we go? In *Transdisciplinarity: Joint Problem Solving Among Science, Technology, and Society: An Effective Way for Managing Complexity*; Thompson, K.J., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R.W., Welti, M., Eds.; Birkhäuser: Basel, Switzerland, 2001; pp. 236–252.
84. Scholz, R.W. Mutual learning as a basic principle of transdisciplinarity. In *Transdisciplinarity: Joint Problem-Solving Among Science, Technology and Society Workbook II: Mutual Learning Sessions*; Häberli, R., Scholz, R.W., Bill, A., Welti, M., Eds.; Haffmans: Zürich, Switzerland, 2000; pp. 13–17.
85. Mittelstrass, J. On transdisciplinarity. In *Science and the Future of Mankind: Science for Man and Man for Science*; Pontifical Academy of Sciences: Casina Pio IV, Vatican City, 2001; pp. 495–500.
86. Flüeler, T.; Scholz, R.W. Socio-technical knowledge for robust decision making in radioactive waste management. *Risk Decis. Policy* **2004**, *9*, 129–159.
87. Heckhausen, H. *Motivation und Handeln*; Springer: Berlin, Germany, 1989.

88. Zimbardo, P.G.; Gerrig, R.J. *Psychologie*, 16th ed.; Pearson: Munich, Germany, 2004.
89. Glynn, S.M.; Aultman L.P.; Owens, A.M. Motivation to learn in general education programs. *J. Gen. Educ.* **2005**, *54*, 150–170.
90. Pintrich, P.R.; Schunk, D.H. *Motivation in Education: Theory, Research, and Applications*; Merrill-Prentice Hall: Upper Saddle River, NJ, USA, 2002.
91. Maslow, A.H. *Motivation and Personality*; Harper & Brothers: New York, NY, USA, 1954.
92. Neher, A. Maslow's theory of motivation: A critique. *J. Humanist. Psychol.* **1991**, *31*, 89–112.
93. Clarke, M.; Islam, S.M.N.; Paech, S. Measuring Australia's well-being using hierarchical needs. *J. Socio-Econ.* **2006**, *35*, 933–945.
94. Yuan, W.; James, P.; Hodgson, K.; Hutchinson, S.M.; Shi, C. Development of sustainability indicators by communities in China: A case study of Chongming County, Shanghai. *J. Environ. Manage.* **2003**, *68*, 253–261.
95. Murray, H.A. *Explorations in Personality*; Oxford University Press: New York, NY, USA, 1938.
96. Carver, C.S.; Scheier, M.F. *Perspectives on Personality*; Pearson Education: Boston, MA, USA, 2004.
97. Larsen, R.J.; Buss, D.M. *Personality Psychology: Domains of Knowledge about Human Nature*; McGraw-Hill: Boston, MA, USA, 2002.
98. Vroom, V.H. *Work and Motivation*; Wiley: New York, NY, USA, 1964.
99. Kahneman, D.; Tversky, A. Prospect theory: An analysis of decision under risk. *Econometrica* **1979**, *47*, 263–291.
100. Tversky, A.; Kahneman, D. The framing of decisions and psychology of choice. *Science* **1981**, *211*, 453–458.
101. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Dec.* **1991**, *50*, 179–211.
102. Bamberg, S.; Schmidt, P. Incentives, morality or habit: Predicting students' car use for university routes with the models of Ajzen, Schwartz, and Triandis. *Environ. Behav.* **2003**, *35*, 264–285.
103. Triandis, H. *Interpersonal Behaviour*; Brooks/Cole Publishing: Monterey, CA, USA, 1977.
104. Deci, E.L. Making room for self-regulation: Some thoughts on the link between emotion and behavior: Comment. *Psychol. Inq.* **1996**, *7*, 220–223.
105. Deci, E.L.; Ryan, R.M. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychol. Inq.* **2000**, *11*, 227–268.
106. Ryan, R.M.; Deci, E.L. Self-Determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* **2000**, *55*, 68–78.
107. Greene, D.; Lepper, M.R. Effects of extrinsic rewards on children's subsequent intrinsic interest. *Child Dev.* **1974**, *45*, 1141–1145.
108. Kyburz-Graber, R.; Rigendinger, L.; Hirsch, H.G.; Werner, Z.K. *Sozio-Ökologische Umweltbildung*; Krämer: Hamburg, Germany, 1997.
109. Jacobs, M. Sustainability as a contested concept. In *Fairness and Futurity*; Dobson, M., Ed.; Oxford University Press: Oxford, UK, 1999; pp. 21–45.
110. Bogner, F.X. The influence of short-term outdoor ecology education on long-term variables of environmental perspective. *J. Environ. Educ.* **1998**, *29*, 17–29.

111. Dettmann-Easler, D.; Pease, J.L. Evaluating the effectiveness of residential environmental education programs in fostering positive attitudes toward wildlife. *J. Environ. Educ.* **1999**, *31*, 33–39.
112. Hesske, S.; Frischknecht-Tobler, U. Transdisciplinary environmental education. Example: Soil and heavy Metals. In *Transdisciplinarity: Joint Problem-Solving among Science, Technology and Society. Workbook I: Dialogue Sessions and Idea Market*; Häberli, R., Scholz, R.W., Bill, A., Welti, M., Eds.; Haffmans: Zürich, Switzerland, 2000; pp. 652–655.
113. Boyes, E.; Stanisstreet, M.; Papantoniou, V.S. The ideas of Greek high school students about the 'ozone layer'. *Sci. Educ.* **1999**, *83*, 724–737.
114. Blewitt, J. *The Ecology of Learning: Sustainability, Lifelong Learning and Everyday Life*; Earthscan: London, UK, 2006.
115. Slovic, P.; Finucane, M.L.; Peters, E.; MacGregor, D.G. Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Anal.* **2004**, *24*, 1–12.
116. Dieleman, H.; Huisingh, D. Games by which to learn and teach about sustainable development: Exploring the relevance of games and experiential learning for sustainability. *J. Clean. Prod.* **2006**, *14*, 837–847.
117. Hansmann, R.; Scholz, R.W.; Francke, C.J.A.C.; Weymann, M. Enhancing environmental awareness: Ecological and economic effects of food consumption. *Simulat. Gaming* **2005**, *36*, 364–382.
118. Pacheco, P.; Motloch, J.; Vann, J. Second Chance Game: Local (university-community) partnerships for global awareness and responsibility. *J. Clean. Prod.* **2006**, *14*, 848–854.
119. Sleet, D.A. Application of a gaming strategy to improve nutrition education. *Simulat. Gaming* **1985**, *16*, 63–70.
120. Torres, M.; Macedo, J. Learning sustainable development with a new simulation game. *Simulat. Gaming* **2000**, *31*, 119–126.
121. Scholz, R.W.; Tietje, O. *Embedded Case Study Methods: Integrating Quantitative and Qualitative Knowledge*; Sage: Thousand Oaks, CA, USA, 2002.
122. Steiner, G.; Laws, D. How appropriate are two established concepts from higher education for solving complex real-world problems? A comparison of the Harvard and the ETH case study approach. *Int. J. Sustain. High. Educ.* **2006**, *7*, 322–340.
123. Mieg, H.A. University-based projects for local sustainable development: Designing expert roles and collective reasoning. *Int. J. Sustain. High. Educ.* **2000**, *1*, 67–82.
124. Posch, A.; Steiner, G. Integrating research and teaching on innovation for sustainable development. *Int. J. Sustain. High. Educ.* **2006**, *7*, 276–292.
125. Hartman, C.L.; Hofman, P.S.; Stafford, E.R. Partnerships: A path to sustainability. *Bus. Strateg. Environ.* **1999**, *8*, 255–266.
126. Nathan, S.; Taylor, N. Linking cooperative education and education for sustainability: A new direction for cooperative education? *Asia-Pac. J. Coop. Educ.* **2003**, *4*, 1–8.
127. Dawes, R.M. Social dilemmas. *Annu. Rev. Psychol.* **1980**, *31*, 169–193.
128. Gärling, T. Value priorities, social value orientation and cooperation in social dilemmas. *British J. Soc. Psychol.* **1999**, *38*, 397–408.

129. Komorita, S.S.; Parks, C.D. *Social Dilemmas*; Brown & Benchmark: Dubuque, IA, USA, 1994.
130. Nordlund, A.M.; Garvill, J. Effects of values, problem awareness, and personal norm on willingness to reduce personal car use. *J. Environ. Psychol.* **2003**, *23*, 339–347.
131. Liebrand, W.B.G.; Van Run, G.J. The effects of social motives on behavior in social dilemmas in two cultures. *J. Exp. Soc. Psychol.* **1985**, *21*, 86–102.
132. MacCrimmon, K.R.; Messick, D.M. A framework for social motives. *Behav. Sci.* **1976**, *21*, 86–100.
133. Schulz, U. *Verhalten in Konfliktspielen*; Verlag Peter Lang: Frankfurt am Main, Germany, 1991.
134. Heberlein, T.A. The land ethic realized: Some social psychological explanations for changing environmental attitudes. *J. Soc. Issues* **1972**, *28*, 79–87.
135. Hopper, J.R.; Nielsen, J.M. Recycling as altruistic behavior: Normative and behavioral strategies to expand participation in a community recycling program. *Environ. Behav.* **1991**, *23*, 195–220.
136. Lüdemann, C. Subjective expected utility, thresholds, and recycling. *Environ. Behav.* **1999**, *31*, 613–629.
137. Schwartz, S.H. Normative influences on altruism. In *Advances in Experimental Social Psychology*; Berkowitz, L., Ed.; Academic Press: New York, NY, USA, 1977; pp. 221–279.
138. Thøgersen, J. Recycling and morality: A critical review of literature. *Environ. Behav.* **1996**, *28*, 536–558.
139. Dietz, T.; Fitzgerald, A.; Shwom, R. Environmental values. *Annu. Rev. Environ. Resour.* **2005**, *30*, 335–372.
140. Dunlap, R.E; Van Liere, K.D. The "new environmental paradigm": A proposed measuring instrument and preliminary results. *J. Environ. Educ.* **1978**, *9*, 10–19.
141. Dunlap, R.E.; Van Liere, K.D.; Mertig, A.G.; Jones, R.E. New trends in measuring environmental attitudes: Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *J. Soc. Issues* **2000**, *56*, 425–442.
142. Stern, P.C. Toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* **2000**, *56*, 407–424.
143. Stern, P.C.; Dietz, T. The value basis of environmental concern. *J. Soc. Issues* **1994**, *50*, 65–84.
144. Grendstad, G.; Wollebaek, D. Greener still? An empirical examination of Eckersley's ecocentric approach. *Environ. Behav.* **1998**, *30*, 653–675.
145. Thompson, S.; Barton, M. Ecocentric and anthropocentric attitude toward the environment. *J. Environ. Psychol.* **1994**, *14*, 137–157.
146. Axelrod, R. *The Evolution of Cooperation*; Basic Books: New York, NY, USA, 1984.
147. Axelrod, R. *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*; Princeton University Press: Boston, MA, USA, 1997.
148. Festinger, L.A. Theory of social comparison processes. *Hum. Relat.* **1954**, *7*, 117–140.
149. Nell, V. Cruelty's rewards: The gratifications of perpetrators and spectators. *Behav. Brain Sci.* **2006**, *9*, 211–224.
150. Sober, E.; Wilson, D.S. Summary of: 'Unto Others. The evolution and psychology of unselfish behavior'. *J. Conscious. Stud.* **2000**, *7*, 185–206.
151. Bandura, A. Selective moral disengagement in the exercise of moral agency. *J. Moral Educ.* **2002**, *31*, 101–119.

152. Bandura, A.; Caprara, G.; Barbaranelli, C.; Pastorelli, C.; Regalia, C. Sociocognitive self-regulatory mechanisms governing transgressive behavior. *J. Pers. Soc. Psychol.* **2001**, *80*, 125–135.
153. De Cremer, D. Respect and cooperation in social dilemmas: The importance of feeling included. *Pers. Soc. Psychol. B.* **2002**, *28*, 1335–1341.
154. Walster, E.; Walster, G.W. Equity and social justice. *J. Soc. Issues* **1975**, *31*, 21–43.
155. Lemert, C. Social ethics? *J. Theor. Soc. Behav.* **1997**, *27*, 277–287.
156. Von Carlowitz, H.C. *Sylvicultura Oeconomica oder Hausswirthliche Nachricht und Naturmässige Anweisung Zur Wilden Baum-Zucht*; Braun: Leipzig, Germany, 1713.
157. Laws, D.; Scholz, R.W.; Shiroyama, H.; Susskind, L.; Suzuki, T.; Weber, O. Expert views on sustainability and technology implementation. *Int. J. Sust. Dev. World* **2004**, *11*, 247–261.
158. Daly, H.E. *Beyond Growth: The Economics of Sustainable Development*; Beacon Press: Boston, MA, USA, 1996.
159. Filho, W.L. Dealing with misconceptions on the concept of sustainability. *Int. J. Sustain. High. Educ.* **2000**, *1*, 9–19.
160. Weigert, A.J. Definitional and responsive environmental meanings: A meadian look at landscapes and drought. *J. Theor. Soc. Behav.* **1997**, *27*, 65–91.
161. Gowdy, J. Economic concepts of sustainability: Relocating economic activity within society and environment. In *Sustainability and the Social Sciences. A Cross-Disciplinary Approach to Integrating Environmental Considerations into Theoretical Reorientation*; Becker, E., Jahn, T., Eds.; Zed Books in Association with UNESCO: London, UK, 1999; pp. 162–181.
162. Hediger, W. Reconciling "weak" and "strong" sustainability. *Int. J. Soc. Econ.* **1999**; *26*, 1120–1143.
163. Krysiak, F.C. Entropy, limits to growth, and the prospects for weak sustainability. *Ecol. Econ.* **2006**, *58*, 182–191.
164. An der Heiden, U. Selbstorganisation in dynamischen systemen (self-organization in dynamic systems). In *Emergenz: Die Entstehung von Ordnung, Organisation und Bedeutung*; Krohn, W., Küppers, G., Eds.; Suhrkamp: Frankfurt, Germany, 1992; pp. 57–88.
165. Burr, V. *An Introduction to Social Constructivism*; Routledge: London, UK, 1995.
166. Boons, F.; Roome, N. Industrial ecology as a cultural phenomenon. On objectivity as a normative position. *J. Ind. Ecol.* **2000**, *4*, 49–54.
167. Evanoff, R.J. Reconciling realism and constructivism in environmental ethics. *Environ. Value* **2005**, *14*, 61–81.
168. Hodge, T. Toward a conceptual framework for assessing progress towards sustainability. *Soc. Indic. Res.* **1997**, *40*, 5–98.