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Behavioral Science and Education for Sustainable Development: Towards Metacognitive Competency

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Abstract: Behavioral science is increasingly considered foundational for addressing various sustainable development challenges. Behavioral change and action competence have also become important goals in Education for Sustainable Development (ESD), complementing and interacting with other educational goals such as the development of sustainability-relevant knowledge, skills, values, and attitudes. We argue that these interconnected learning goals of ESD can be advanced by integrating interdisciplinary behavioral science concepts, methods, and insights into the design of curricula, learning environments, and processes for participatory whole-school approaches. Specifically, we highlight the role of metacognitive competency in self-directed individual and collective behavior change and we present our educational design concept for teaching human behavior as an interdisciplinary theme in ESD.

Keywords: education for sustainable development (ESD); behavioral science; interdisciplinarity; metacognition; competencies; curriculum design

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1. Introduction

Behavioral dimensions play a central role in diverse challenges of social, economic, and ecological sustainable development–from the prevention of physical and mental health problems [1–3], to pro-environmental individual behavior [4,5], lowering resource consumption [6], collaborative management of natural resources [7], international cooperation [8], climate change [9,10], and reduction of biases and prejudice [11,12]. Behavioral science has also emerged as an interdisciplinary field of study in recent decades, whose role in addressing issues of sustainable development is being increasingly recognized, such that the UN has instantiated a behavioral science platform and 200 countries have created behavioral science units [13,14]. Similarly, the recognized role of human behaviors and behavioral science in sustainable development has led to an increased emphasis on behavioral change as well as on more action-oriented competencies in Education for Sustainable Development (ESD, e.g., [15,16]).

In this article, we ask what these developments suggest for the development of curricula and competencies in ESD. Specifically, what should learners—from primary to tertiary education—know about (the science of) human behaviors, and why? We argue that targeting student conceptual understanding (sensu [17])—i.e., deeper, networked, and transferable understandings about the causes, consequences, diversity, and flexibility of human behavior–needs to be a core focus of ESD. This is because such understandings may foster learners' metacognition in relation to developing a variety of competencies in ESD. Here, we will present our arguments for the role of metacognitive competency in ESD, and we will present an educational design concept that we have developed with the aim to foster the development of this metacognitive competency related to human behavior in learners.

The article is structured as follows: In the remainder of the introductory section, we outline what we mean by behavioral science as well as summarize some recent discussions within the field that are relevant for the purpose of this article. In Section 2, we summarize commonly outlined elements and learning goals of ESD programming and highlight the increasing emphasis on behavior change and action competence. In Section 3, we outline the role of mental models in behavior and competency development, and how the development of metacognitive competencies, informed by behavioral sciences, might help shape helpful mental models about human behavior and advance competencies in ESD. Section 4 constitutes the main part of the article, in which we present our educational design concept for teaching human behavior as an interdisciplinary theme towards the development of metacognitive competency. In Section 5, we propose questions that educators can ask themselves in order to apply the design concept in their educational contexts. Section 6 gives an outlook on future research and invites the reader to use our design concept to inform future curriculum development.

Behavioral Science

Human behavioral science has become an interdisciplinary field of study. In this context, there is no universally agreed upon understanding of what counts as "behavioral science", sometimes it's understood more narrowly as the field of "behavioral economics", while other times it is understood more broadly and integrates various schools of thought spanning across the natural and social sciences as well as humanities, including economics, anthropology, sociology, various branches of psychology, political science, biology, ecology, (cultural and biological) evolution, and computer science or digital humanities [14,18]. Similarly, there is in fact no universally agreed upon understanding of what counts as "behavior" [19]. For example, many behavioral scientists only regard observable, i.e., "overt" behaviors as behaviors [13,19], while others particularly in psychology and cognitive sciences, also regard "covert" behaviors such as thoughts and feelings as behaviors.

Here, we integrate numerous disciplines and hence refer both to a broader conceptualization of behaviors and a broader notion of behavioral sciences. Taking a pluralistic and interdisciplinary view is warranted since understanding, predicting, and influencing human behaviors is inherently complex. For example, in recent years, the field of psychology has become aware of numerous problems regarding the generalizability of their findings given the heterogeneity and complexity of causes of human behaviors [20]. Henrich et al. [21] have also drawn attention to the fact that psychological research has largely sampled people from a small subset of global society, namely from Western, educated, industrialized countries, and falsely generalized findings to all of humanity. This has spurred more cross-cultural research in the last decades [22]. Further below we will also expand on why the inclusion of thoughts, feelings, values etc. within the concept of behavior can be pedagogically valuable for the development of competencies.

Overall, there is some recognition that methods, theories, and assumptions of different disciplines concerned with human behavior are not yet sufficiently aligned or coherent, sometimes conflicting with one another, and that this incoherence stifles progress in our understanding and tackling many of the societal problems that are related to human behavior [18,23–26]. For example, Tavoni & Levin [26] highlight how applying models of human behavior that are incongruent across disciplines may lead to real-world negative outcomes because of the different assumptions about how humans will react to certain policy interventions. For example, material incentives (taxes, fines, discounts, premiums etc.) that are aimed at motivating certain human behaviors, designed from a *Homo economicus* model (an economic model of human behavior by which humans are conceptualized to act in ways to maximize personal short-term material benefits and which is now seen as an abstraction largely incongruent with evidence, e.g., [27]), may sometimes backfire, leading people to abandon their intrinsic motivations and preferences for prosocial behavior [28]. The field of behavioral economics, an important driver of current behavioral science developments, has also been criticized for relying too strongly on individual decision making dynamics in the form of heuristics and biases, and for not sufficiently integrating considerations from bio-cultural evolutionary science [14,29]. Furthermore, the predominant focus on individual behavior change in behavioral science, to the detriment of focusing on system-level change, has also been criticized [30]. Similarly, among contextual behavioral scientists, there is criticism of an individualized and decontextualized approach to human behavior change and well-being that does not sufficiently take into account the role of context and function of behaviors, and that does not sufficiently build on our understanding of human language and cognition [5,31]. Others have highlighted the legitimate role and value of pluralism in the social sciences, where different kinds of disciplinary explanations can coexist [32]. Thus, striving for pluralism by exploring various disciplinary perspectives on human behavior, while also aiming for coherence across these perspectives, can be considered a helpful strategy [33].

2. Elements and Goals of ESD Programming

In this section, we summarize commonly outlined elements and learning goals of ESD programming and draw attention to the increasing focus on behavioral change and action competence, with the aim to highlight novel opportunities that we build on later in the article.

ESD aims to empower learners "with knowledge, skills, values and attitudes to take informed decisions and make responsible actions for environmental integrity, economic viability and a just society empowering people of all genders, for present and future generations, while respecting cultural diversity." [15] (p. 8).

Towards this aim, ESD is meant to address the four dimensions of learning content, learning outcomes, pedagogy and learning environment, and societal transformation [15,34]. The UNESCO Roadmap 2030 [15] also highlights the role of cognitive, social-emotional, and behavioral dimensions of learning, and their integration, in achieving competencies for transformation.

The dimension of learning outcomes is about the promotion of certain competencies in learners (while some scholarship distinguishes between "competence" and "competencies", these concepts are often used interchangeably in education literature, and we use these synonymously here as well, or in ways that reflects common usage in specific instances, as in "action competence"). Competencies are understood to comprise knowledge, skills, values, and attitudes and to emerge from integration of the cognitive, social-emotional and behavioral learning domains [15]. The cognitive domain is about developing certain knowledge and skills, while the socio-emotional learning dimension is about developing values, attitudes, and motivations for sustainability, including the cultivation of a sense of belonging to a common humanity, sharing values and responsibilities, empathy, solidarity and respect for diversity and the planet, as well as a sense of responsibility for the future. The behavioral learning dimension is about involving learners in taking "practical action for sustainable transformations in the personal, societal and political spheres" [15] (p. 17).

A number of publications have put forth competency frameworks and learning goals considered central in ESD [35–37]. Such competencies for ESD often include systems thinking, cooperation competency, normative or evaluation competency, critical thinking, self-regulation or self-awareness, future thinking or anticipatory competence, strategic actionk and integrated problem solving competencies. Sass et al. [38] integrate several of these competencies in their conceptualization of action-competence for ESD, including future thinking, critical thinking, systems thinking, cooperation and intercultural competence.

As mentioned above, an increasing emphasis on behavior change and action competence is noticeable in the development of ESD programming. For example, the first UNESCO Roadmap on ESD [34] only contains the word behavior once, while the 2020 document [15] contains the word 16 times. Several publications have explored the impact of ESD on behaviors and action competencies (e.g., [39–41]), or have proposed educational design frameworks for fostering these outcomes. Sinakou et al. [16] propose the "Holism-Pluralism-Action-orientation in ESD framework" for the research and design of learning environments in ESD, building on previous work by [42]. Sass et al. [38] have conceptualized the concept of action competence for ESD as involving several components, including knowledge of issues, action possibilities and norms; skills such as critical thinking and flexibility; confidence in one's own capacities and influence; and willingness and passion to act.

This stronger focus on behavior change can be attributed to the recognized knowledge-action and values-action gaps. These concepts describe the discrepancies that are observable between the amount of knowledge that someone has about a particular issue, or the attitudes and concerns that someone might express related to a particular issue (e.g., climate change, health), and the behavior they engage in (e.g., [43–45]). Arbuthnott [46] already pointed out that ESD needs to focus more strongly on the complex causes of behavioral change rather than just on changing values and attitudes. Various authors have emphasized how behavioral change efforts in areas such as health and pro-environmental behavior can fail or backfire when perspectives from the social, psychological, and behavioral sciences are not taken into account (e.g., [5,47–49]. Toomey [50] recently summarized the knowledge-action gap in her article titled "Why facts don't change minds". Others have similarly criticized so-called "knowledge deficit", "enlightenment" or rationalistic models of science communication, which assume that societal support for various scientific issues or respective changes in attitudes and behaviors can be achieved by sufficient factual knowledge [51,52].

However, at the same time, the dimension of learning content in ESD tends to be understood as involving the teaching about a diversity of sustainability issues (spanning all of the 17 Sustainable Development Goals), such as climate change, biodiversity loss, sustainable production and consumption [15,34]. Similarly, the cognitive learning dimension is thought to entail an understanding of the ecological, social and economic dimensions of sustainability challenges and their complex interlinkages [15]. In this regard, in their conceptualization of action competence for ESD, Sass et al. [38] include action-oriented knowledge and skills as important components of action competence. Types of knowledge include issue-related knowledge, knowledge about action possibilities, as well as knowledge of personal and social norms. The role of inter- or transdisciplinarity and holistic, pluralistic approaches in ESD are also often emphasized due to the complex and "wicked" nature of sustainability issues. For example, Sinakou et al. [16] include interdisciplinarity in their "Holism-Pluralism-Action-orientation ESD framework". As already hinted at above, human behavioral dimensions greatly add to this complexity and wickedness of sustainability issues. In this regard, it is interesting to note that the "learning content" and "cognitive learning" dimensions, as well as the knowledge components for action competence [38] tend to be understood to largely entail environmental as well as social and economic aspects of specific sustainability issues. As highlighted in [15] (p. 9), "ESD is mostly associated with the teaching of scientific knowledge on environment. This is not enough to bring the transformative power of education to its full force." As we will argue below, however, it is worth considering within the "learning content", "cognitive learning" and "knowledge" dimensions the integration of behavioral science concepts and methods, including those that are involved in various sustainability issues as well as in social-emotional and behavioral learning, towards the development of action competence.

ESD programming also advances changes of pedagogy towards more learner-centered, experiential, active and transformative methods [15,34], building on a constructivist notion of how competencies are developed. This emphasis can be considered to stem from the above-mentioned knowledge-action and values-action gaps and the hopes that more experiential and action-oriented pedagogy will enable learners to acquire certain skills and attitudes to reorient their own behaviors and motivate others to contribute to sustainable development, i.e., action competence.

Finally, ESD programming also increasingly emphasizes the need for whole-institution approaches in which "we learn what we live and live what we learn" [15] (p. 3). That is, sustainability should not only be a theme taught in classrooms, but schools as institutions need to model and integrate sustainability in their infrastructure, policies, and cultures, especially through the participation of all stakeholders, including students, allowing learners to apply their knowledge and competencies towards institutional and societal transformation. Similarly, the Holism-Pluralism-Action-orientation in the ESD framework by Sinakou et al. [16] includes community involvement as an important component for the design of effective learning environments in ESD.

3. Competencies in ESD: The Role of Mental Models and the Case for Metacognition

In this section, we outline the role of mental models in behavior and competency development. We also introduce the notion of metacognitive competencies and propose that the development of metacognitive competencies, informed by behavioral sciences, might help shape helpful mental models about human behavior and advance competencies in ESD.

One aspect of knowledge that is relevant to competency development and behavior change are mental models. In cognitive science, mental models are understood to be "personal, internal representations of external reality that people use to interact with the world around them", which are "constructed by individuals based on their unique life experiences, perceptions, and understandings of the world" and "used to reason and make decisions" [53] (p. 1). Jones et al. [53] highlight how making explicit and sharing stakeholder mental models can foster understanding, social learning, and collective decision making in the context of natural resource management.

We argue that for the purposes of competency development in ESD, mental models about human behavior might be of particular interest because of their role in affecting how humans notice, interpret and react to their own and others' behaviors.

In general, the mental models that students or the general public might have about human behavior may be far from clear, highly diverse, conflicting with various current scientific understandings, and may lead to negative outcomes in terms of actual behavior. For example, being trained in the traditional economic *Homo oeconomicus* model of human behavior can have real-world impacts on how humans make decisions and behave towards other humans, leading to a kind of self-fulfilling prophecy of self-interested behaviors and low cooperation [54–56] (though there is debate about the direction of causality in these observed associations). Similarly, people's beliefs about the role of luck in unemployment or poverty influence the degree to which they support redistributive social welfare programs [57]. More generally, research on the role of mindsets and beliefs highlights the role that mental models about human behavior play in affecting actual behaviors [58]. For example, the concept of growth mindset [59] proposes that a belief regarding intelligence as a largely fixed, non-changeable attribute, may demotivate learners to challenge themselves and learn from mistakes. Similarly, beliefs about what makes up well-being have been shown to correlate with actually experienced well-being through the kinds of behaviors that are motivated by such beliefs [60,61].

It seems that such diversity of more or less implicit mental models of human behavior may provide substantial obstacles towards addressing sustainability challenges; or concurrently, shaping mental models about human behavior may provide substantial drivers for affecting social-emotional and behavioral change. In general, complex systems scholars regard mental models, as well as the ability to transcend mental models through a kind of metacognitive reflection on the limits and changeability of mental models, as among the most important leverage points for transforming systems [62]. To build on the title of one publication mentioned above regarding the limits of factual knowledge in affecting behavior change, i.e., "facts don't change minds" [50], it might be more appropriate to ask "which facts change minds", and to consider that some facts do change minds, namely facts–or ideas–about human behavior.

What then, is the role of behavioral science perspectives in ESD for the development of competencies and helpful mental models in learners? Overall, one pathway for the integration of behavioral science in ESD is to use insights and methods to affect attitude and behavioral change of students and other school stakeholders, such as through the shaping of learning environments, policies, and whole-school approaches. For example, nudging [63,64], messaging and social marketing campaigns [65], or gamification [66,67] may be used to motivate students to engage in certain behaviors. Immersing learners in certain environments and experiences might also affect their future behavior. For example, research on nature experience has shown that experiences in nature during childhood can be positively associated with pro-environmental actions in adulthood [68].

However, we argue that this limits the use of behavioral science in ESD to aspects that are not open to the metacognitive reflection, competency development, and transformation of learners and their mental models. Furthermore, such use of behavioral science in ESD might contribute to and not help resolve concerns about indoctrination of certain values, attitudes, and behaviors [38,64,65]. As Sinakou et al. [16] highlight, "the objective of ESD is not a behavioral change but rather the development of skills such as participatory and active citizenship skills, cooperative skills and independent and autonomous thinking and learning so that students are capable of dealing with the complex and changeable reality" (p. 3). Similarly, Sass et al. [38] note that "ESD is bound to move away from a normative tradition in which the purpose of education is to teach students about the 'right' sustainable behavior (...) gradually moving toward a more democratic and 'pluralistic' tradition, that offers students the opportunity to find their own voice among different perspectives (..) This allows for a more volitional approach to (sustainable) behavior in the spirit of 'action' "(p. 4). Consequently, in their conceptualization of action competence Sass et al. [38] also highlight that "Action differs from mere behavior in that it is decided upon by the agents themselves, and from an 'activity' in that it is aimed at solving an issue" (p. 4).

We agree with these authors in highlighting that mere behavior and behavioral change or mere activity are not the same as competency and cannot by themselves be the targets of an ESD that aspires to go beyond socialization and transmission of specific "right" behaviors. In this regard, we argue that the various competencies in ESD can be advanced by an underlying metacognitive competency that develops through the integration of conceptual understanding of human behavior and the regular reflection as well as application of these understandings to one's own behaviors and social-cultural environments.

As in the case of the concept of behavior, there is no universally agreed on conceptualization of metacognition. In the field of education, metacognition is often understood as cognition about cognition entailing declarative and procedural knowledge elements, i.e., knowledge about cognition and factors that influence it as well as knowledge about strategies and other procedures to plan, monitor, regulate, and evaluate cognition [69].

In education, metacognitive competency is also usually targeted and referred to in the context of learning, i.e., the learner's ability to monitor their own learning, knowledge about learning and use of strategies to self-regulate their learning [70,71]. However, metacognitive competency can equally be relevant and applicable not just for the self-regulation of learning but of numerous behaviors, including behaviors involved in the above competencies such as cooperation, critical thinking, self-regulation, evaluation, future thinking, and ultimately, action competence.

For example, for a metacognitive self-regulation of cooperative behavior, students can benefit from knowledge and awareness of humans', including their own, cooperative and prosocial tendencies, their psychological needs and values in relation to social belonging and shared identity, of factors that foster and hinder cooperation, as well as knowledge of strategies that can help foster cooperation in themselves and others [72]. Similarly, for a metacognitive self-regulation of critical thinking, students can benefit from knowledge about the human mind and common biases and pitfalls that may hinder their ability for critical thinking, as well as strategies for noticing, monitoring, and evaluating their thinking [12,73]. For a metacognitive self-regulation of action competence, students can benefit from, not just knowledge about issues and possible actions, but also about the causes of human behaviors including the factors that may hinder or foster action towards valued outcomes, as well as knowledge about strategies such as values clarification, goal-setting, habit tracking, mindfulness, nudging, team-building, or various methods of collective decision making, to motivate and persist in individual and collective behavior change efforts.

In this regard, it may be of particular interest for the ESD community that the interdisciplinary behavioral sciences are developing various applied approaches to evolving behaviors and cultures towards positive real-world outcomes. One such example is the research on fostering intellectual humility, perspective taking, and constructive dialogue by training about cognitive biases and moral intuitions [12,74]. Another applied example is provided by the ProSocial approach [72], which is a unique model for community building, cooperation and group facilitation, in that it synthesizes numerous fields of behavioral science and identifies overarching principles of evolution and behavior change, allowing the application to various contexts of social life. A sub-component of ProSocial is the construct of psychological flexibility [75], informed by contextual behavioral science (CBS). There is a growing evidence base for how applied methods of CBS, which often involve education on dynamics of human behavior, have positive outcomes for mental health and values-oriented living [76,77].

Thus, we argue that metacognitive competency underlying the self-directed development and regulation of competencies in ESD can be advanced by focusing instruction on conceptual understanding of human behavior and the application of various tools and methods to help students become aware of, reorient, monitor, and evaluate their own behaviors and the behaviors of others in relation to these competencies.

Furthermore, in line with the role of holistic, interdisciplinary approaches in ESD [16], this conceptual understanding of human behavior requires the integration of a variety of disciplinary perspectives, rather than, e.g., just a behavioral economics, sociological, biological, or psychological perspective.

In the following section we present our educational design and development efforts aiming to integrate human behavior as an interdisciplinary focal theme in ESD towards the development of metacognitive competency.

4. An Educational Design Concept for Teaching Human Behavior as an Interdisciplinary Theme

In this section, we first outline some challenges that might exist for the integration of behavioral science in school and teacher education curricula. We then present our educational design concept for integrating human behavior as an interdisciplinary theme in general primary and secondary as well as teacher education with the aim to draw educators' attention to the theme of human behavior across subjects, and to develop learners' mental models as well metacognitive competency in relation to human behavior.

Overall, the integration of behavioral science in school curricula might present various challenges: the strength of behavioral science as a highly interdisciplinary field of study, connecting many subject areas and relevant to many topics, may also be simultaneously its predicament: Human behavior can end up being 'everywhere and nowhere' in the primary and secondary school curriculum or in ESD programming. After all, in the majority of education contexts there is no school subject 'human behavior' and, while some schools may offer a psychology elective, it is not otherwise obvious in which subject(s) students would be exposed to the core concepts of behavioral sciences in a holistic, interdisciplinary manner. In curriculum guidelines for ESD (e.g., [36,78]), reflections on human behaviors and their consequences are often an implicit thread through topics and learning goals, but there seems to be relatively little emphasis on exploring and applying the core concepts and principles of behavioral science themselves. While psychology might exist as a subject in some education contexts such as the US and in the International Baccalaureate program, the concepts and topics explored in psychology might not be well connected to those explored in biology, history, or economics. Overall, biology curricula may or may not include behavioral biology in their standards, and if they do, this may or may not include human behavioral biology. For example, in the edited volume on 'Biology Education for Social and Sustainable Development' by Kim & Diong [79], we find no reference to the notion of exploring biological perspectives on human behavior as content within ESD. Regarding economic perspectives on human behavior, Seeber & Birke [80] lamented that the importance of social dilemmas is often not sufficiently emphasized in curricula of other subjects. Yet, the causes of sustainability problems can often be framed as such dilemma situations between what is best for individuals (or sub-groups) in the short term, and what is best for the community (as a whole) in the long term.

The US National Academies of Science [81] also discussed pathways for the integration of social and behavioral sciences in the US curriculum, motivated by the recognition that, on the one hand, social and behavioral sciences serve an important role in equipping students with knowledge and skills to understand human and social phenomena, make better decisions, and contribute to society, and on the other hand, social and behavioral sciences are not adequately represented in primary and secondary education to the same extent that natural science subjects are. Given the recognized problem of curriculum overload in many countries [82], the US National Academies of Science [81] (p. 7) suggested that "one approach might be to work for the inclusion of [social and behavioral sciences] in math, reading, science, and other curricula, rather than attempting to carve out a separate [social and behavioral sciences] territory in the school day".

In short, we suspect that current school curriculum structure can create a blind spot regarding the development of interdisciplinary (i.e., pluralistic, holistic) conceptual understandings of human behavior that can serve as a foundation for a more metacognitive action competence.

To alleviate this challenge and to place the theme of human behavior in the center of instruction across subjects towards the development of metacognitive competency, we have developed an educational design concept. The elements of the design concept have been identified over time (e.g., [83]), informed by interdisciplinary behavioral sciences, educational best practices, as well as our experiences and educational design research in secondary and teacher education contexts. The concept is subject to continuous reflection and adjustment based on its usefulness for educators and curriculum developers.

The design concept aims to provide a parsimonious yet comprehensive set of guidance for educators in the choice of content and teaching methods as well as in the development of learning environments and curricula with the aim to develop in students a core set of overarching understandings and skills that characterize the interdisciplinary behavioral sciences and are transferable across a wide range of sustainability-relevant issues that all humans across cultures face.

Based on our design concept, we have developed a wide range of lessons for secondary and undergraduate classrooms, a Teacher's Guide [84]; and a teacher training module for future primary and secondary school educators across all subject areas, all housed within an open online research and learning hub (https://openevo.eva.mpg.de/) (accessed on 15 March 2023).

The following sections present the core elements of our design concept and their rationales in more detail: learning goals, three overarching design principles, nine content anchors, six thinking tools, as well as pedagogical approaches.

4.1. Learning Goals

Common competencies in ESD are the central learning goals we strive to support with our design concept. We add to these further competencies and attitudes often included in 21st century education, such as growth mindset, intellectual humility, design thinking, and intercultural competence (Figure 1). This list of target competencies is not exhaustive because the aim is primarily to highlight that many 21st century competencies and attitudes can be supported by an underlying metacognitive competency that integrates, on the one hand, conceptual understanding of human behavior (especially of those behaviors that are involved in the development of a particular competency or attitude), and on the other hand, the practicing of adaptive flexibility. By conceptual understanding, we mean to highlight that the cognitive dimension of learning is not merely about developing knowledge of facts around certain topics, but about developing an understanding that transcends specific topics and phenomena and is transferable across them (sensu [17,85,86]). A conceptual understanding of human behavior in particular should be transferable to everyday experience and diverse issues of sustainable development. By adaptive flexibility, we refer to the ability to persist or reorient behavior in the service of one's values, building on the notion of "psychological flexibility" as advanced by the field of CBS [75,87] (see also Section 4.4.4.).

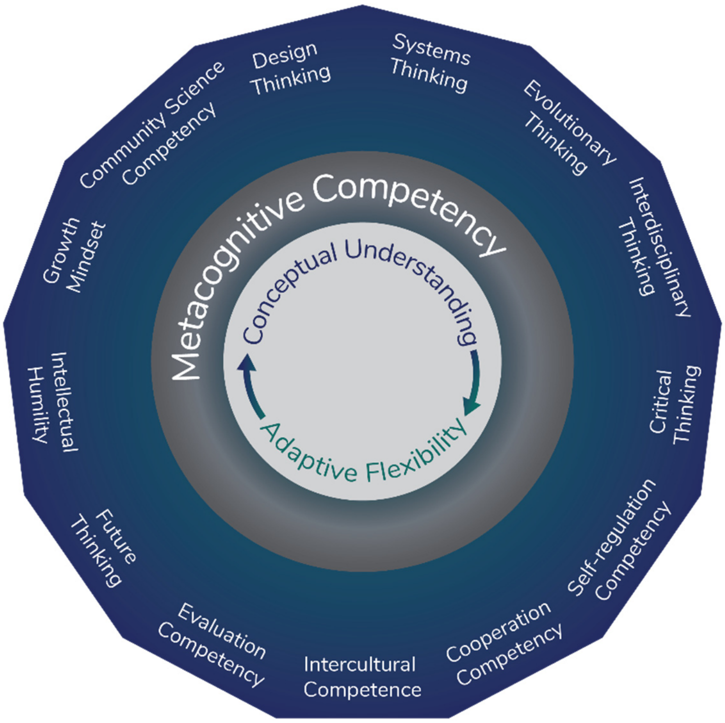


Figure 1. Learning goals of our design concept, with a focus on the development of metacognitive competency through the integration of conceptual understanding of human behaviors, particularly those involved in each of the competencies, and the practice of adaptive flexibility.

4.2. Design Principles

Three guiding design principles are the highest-level generalizations of our approach to ESD from a behavioral science perspective. They are meant to focus the choice of content and methods across subjects on behavioral dimensions of phenomena. In what follows we will introduce the three guiding design principles, i.e., (1) focus on human behaviour, (2) explore complex causality, and (3) teach for transfer of learning.

Focus on human behavior. Focus on the aspects and everyday experience of human behaviors relevant to human well-being and sustainable development (e.g., prosociality, cooperation, sense of belonging, trust, curiosity and creativity, innovation, cognitive biases, learning and teaching, imitation, social norms and norm psychology, empathy and compassion, sense of fairness, language, perspective taking, flexibility, self-control, goals and values, well-being, future thinking).

As we highlighted above, the cognitive or knowledge dimension of ESD might typically be associated with learning about the ecological, technological, economic, or political aspects of certain sustainability challenges. We argue that the cognitive dimension of ESD should also include behavioral aspects of various sustainability challenges. For each sustainability problem, we can identify numerous individual and collective human behaviors that are associated with or even contribute as causes or solutions to the problem and it is important for students to recognize these behavioral dimensions of issues. In a similar vein, Stern et al. [86] regard human experience concepts as central conceptual foci for instruction across disciplines in 21st century education, highlighting that "Human Experience Concepts are the organizing ideas that help us to better understand who we are as individuals and as a collective species, and are inherently complex and interesting, especially to young people as they navigate and seek to understand who they are in the world." (p. 81). Importantly, while many of these behaviors are central to everyday experience, that does not mean that they have been metacognitively reflected by students. Using various pedagogical approaches (see below) students should be supported in reflecting on and constructing meanings of these behaviors and concepts, to lay the groundwork for conceptual change and transformation.

For example, according to Sass et al. [38], action competence involves knowledge about future visions and about individual and social norms. We argue that students need opportunities to notice the role that future thinking might play in their everyday life and behavior as well as in society, in the past, present and future. Similarly, students need opportunities to notice the social norms that surround them, that guide their behavior and that affect various sustainability problems. However, we argue that beyond norms and future visions, there are many other behavioral dimensions and concepts (such as the ones listed above) that students need to notice and have an understanding of in order to develop and self-regulate their action competence.

Explore complex causality. Explore and reflect on the many causes and consequences of human behavior and on the complex causal relationships in human evolution, behavior, and social-ecological systems.

Here, an important goal is to move beyond noticing, and then evaluating certain behaviors as desirable or not desirable, to an understanding of why certain patterns of behavior might exist in the first place: How do immediate internal and external factors, as well as individual development, cultural and evolutionary history, impact human behavior? What might be people's motivations to behave in one way or another? What consequences do behaviors have for individuals and their environment, in the short-term and in the long-term, i.e., what are the functions of behaviors in terms of individual wellbeing and sustainable development? Why and how do certain behaviors, including beliefs, norms, and attitudes, spread in society? And what implications do answers to these questions have for exploring and evaluating solutions to sustainability problems? Diverse content and thinking tools informed by the behavioral sciences (see below) can help in reflecting on these questions and developing understandings.

In line with views from CBS, we propose that exploring the causes of human behaviors helps students focus on the contextual conditions in which behaviors occur and that influence behavior, enabling them to consider the conditions that need to be changed in order to affect behavior change in themselves and others. Furthermore, exploring the functions and consequences of behavior can help in understanding why humans engage in certain behaviors and to evaluate behaviors in relation to individual and shared values. Furthermore, informed by views in CBS regarding the role in psychological flexibility of acceptance and of an "observer stance" to experience, as well as common conceptualizations of mindfulness as involving non-judgmental acceptance and openness [88], we propose that exploring the diverse causes of human behaviors can serve to help students view their own experiences and behaviors as well as the behaviors of others from new perspectives and in ways that may foster such openness and acceptance.

For example, the framework of action competence by Sass et al. [38] involves knowledge about individual and social norms. We argue that such knowledge should also include an understanding of where social norms come from and why it is that social norms play such a strong role in the behaviors and cultures of our species [89], how social norms develop, spread, can change in a population [90], and how variable they are cross-culturally (e.g., [91–93]). This understanding lays the groundwork for a more flexible and metacognitive approach to decisions about which social norms to adopt in one's own behaviors, and to imagining and crafting new social norms individually and collectively.

Teach for transfer of learning. Ensure students practice transfer of understandings to novel phenomena, everyday experience, and relevant problems of sustainable development across multiple scales and contexts of society, e.g., with the help of analogy maps and other thinking tools.

Our focus on transfer of learning is motivated by the overall role that transfer has in education [94]. As Willingham [95] highlights in the context of critical thinking, "If knowledge of how to solve a problem never transferred to problems with new surface structures, schooling would be inefficient or even futile" (p. 22). The particular strength of behavioral science concepts lies in their transferability across a multitude of sustainability challenges. For example, van Bavel et al. [3] outline a number of behavioral concepts relevant for addressing the COVID-19 pandemic, including threat perception, trust, science communication and conspiracy theories, morality, and stress. These and other dimensions do not only play a role for understanding human decisions and behaviors during the pandemic, but also in relation to many other issues such as climate change. Furthermore, a set of behavioral science concepts, principles, and tools can be used to analyze and compare multiple kinds of behaviors (see below). However, seeing how these apply across problems that are, on the surface, quite different (e.g., climate change, a global pandemic) requires particular pedagogical approaches that help students see the deep structure of diverse phenomena. Various pedagogical methods can help develop students' ability to transfer their learning, including comparisons of cases by deeper principles, reflection prompts and guiding questions that ask students to look for previously learned concepts and principles in new phenomena, and analogy mapping [86,96,97].

For example, the framework of action competence by Sass et al. [38] involves knowledge about individual and social norms. We argue that educators need to focus on enabling students to see the workings of social norms across diverse contexts and to transfer their understandings about the causes and consequences of social norms across these contexts, using appropriate pedagogical tools.

At the same time, the problems of "overzealous transfer" or negative transfer need to be addressed [98]. For example, laboratory experiments in behavioral science, cooperation games, or computer simulations of social-ecological systems are abstractions of the real world and interpreting their results or deriving conclusions about solutions in the real world requires critical transfer, i.e., recognizing in what way situations are both similar *and* different and recognizing the limits of the transferability.

4.3. Content Anchors

In order to explore human behavior more concretely and to implement especially design principles two and three (explore complex causality and transfer), we have identified nine content anchors that reflect a range of cross cutting methods, perspectives, applications, and fields of study spanning evolutionary, behavioral, and sustainability sciences (Figure 2). Focusing classroom content, instruction, and reflection on these content anchors helps learners understand and reflect on the complex evolutionary, cultural-historic, developmental, and proximate causes and consequences of human behavior and their relation to everyday life, well-being, and sustainable development.

For example, exploring behaviors across different species such as between humans and other primates can help students understand the evolutionary causes of our human traits and their functions today, or can help students understand deeper principles of cooperation and sustainability. In [99] we present a study which explored student and teachers' views on the cooperative abilities of human children compared to chimpanzees in a set of behavioral experiments, and we highlight the educational potential of such content in driving reflection and discussion of mental models about what makes us human.

Exploring human behaviors across cultures can help students understand and appreciate the cultural diversity and flexibility of our species, build intercultural competence, understand the role of social norms on our behaviors, as a foundation for exploring ways of creating new social norms (e.g., [93,100]). Such cross-species, cross-cultural, and developmental explorations can also support attitudes such as a sense of "common humanity" [15].

Figure 2. Content anchors in our design concept, as perspectives to explore human behaviors.

Exploring different situations of common-pool resource management in the world, such as a local watershed, fisheries, forests, or the global climate, can help students understand the conditions and mechanisms that can foster or hinder sustainable resource use (e.g., [101,102]) and critically transfer their understandings to novel common-pool resource problems from the local to the global levels. Exploring different behaviors of their minds, and their possible origins, may help students become more mindful and accepting of their inner experiences, as a foundation for reorienting their behavior towards their self-chosen values. Playing cooperation games in the class (e.g., [103,104]) or exploring game theoretic experiments and their outcomes (e.g., [105]) can help students understand the challenges of cooperation, ways to overcome them, and the human behavioral dynamics that foster and hinder cooperation in social interactions. Exploring agent-based computer simulations of social-ecological systems (e.g., [106]) can help students develop systems thinking competencies as well as transferable understandings of how behaviors of individuals interact to create emergent outcomes on system levels, and explore conditions that help foster cooperation and sustainable resource use.

The list of content anchors is not meant to be exhaustive but open to expansion. However, we believe that this set of nine content anchors fulfills a number of pedagogical needs: it represents the structure of interdisciplinary behavioral sciences in a manner that is accessible to teachers and students, and allows the exploration of human behavior from multiple perspectives; it helps to focus instruction on factors and concepts that students can link to their existing understandings and experiences; and/or it helps to focus on factors that students can influence with their own behaviors.

4.4. Thinking Tools

Another category of our design concept is a collection of thinking tools. They represent an expanding conceptual and pedagogical toolkit of analytical perspectives used by behavioral scientists to explore the causes and consequences of human behavior. In the same way, using these tools across content can help complexify and deepen students' understanding of causality in human behavior and sustainable development. In the service of developing metacognitive competency, these tools also present strategies to help students plan, monitor, evaluate and thus regulate their own behaviors as well as the collective behaviors of their communities.

4.4.1. Tinbergen's Questions

In 1963, ethologist Niko Tinbergen [107] proposed four questions that can be used to understand the various causes of animal behavior:

- Proximate mechanisms: What are the immediate triggers and proximate physiological and psychological mechanisms that cause the behavior?
- Development: How does a behavior develop over a lifetime?
- Evolutionary history: When in the phylogenetic history of the organism did the behavioral trait emerge?
- Function or adaptive value of the behavior: What is the function or adaptive value of the behavior that causes an individual to repeat the behavior (or not), or that leads to the behavior becoming more or less common in a population?

This set of four questions is still influential today in how behavioral and evolutionary scientists attempt to explore the causes of human and animal behavior (e.g., [108–110]) and even the behaviors of machine intelligences [111]. However, various additions and modifications have also occurred over the years since some of the original formulations present the state of the field of ethology and evolutionary biology 60 years ago and demand some updates.

Dewsbury [112] reviewed and synthesized the numerous other frameworks beyond Tinbergen's that have been proposed for the study of animal behavior. For example, he expanded the notion of "function" or "adaptive value" in terms of consequences of a behavior for the organism itself, other organisms, and the environment. He also included culture/cultural history as an additional set of causes (see also [113]), and differentiated between internal and external factors influencing behavior. Overall, one might generalize the question of evolutionary or phylogenetic history to simply the "history of the population of the organism", thus including family and cultural history. In a similar vein, Sapolsky [114] conceptualized the causes of human behavior in terms of zooming out further and further back in time to explore proximate (e.g., neurological, hormonal), developmental, and historic (cultural-historic, evolutionary) causes, thus grouping three of Tinbergen's questions on a time dimension. Others have also reorganized the four questions in different ways or added different levels of analysis [109,110].

Ariew and Panchanathan [115] also proposed to expand or reinterpret Tinbergen's questions further by integrating agency and the organisms' goals. In this regard, it needs to be highlighted that Tinbergen's questions were developed in the field of animal ethology and thus largely focus on observable (overt) behaviors, in an attempt to rid the field of obscure teleological, anthropomorphic explanations of animal behavior. As mentioned in the introduction, in some branches of behavioral science also today, the covert behaviors of humans, including feelings, thoughts, goals etc. are usually not considered useful or acceptable causes since they cannot be observed, measured, and directly changed. However, in many branches of psychology, we find that thoughts, feelings, goals, values, intentions etc. are termed covert behaviors which in turn are considered acceptable causes of overt behaviors. Furthermore, for pedagogical purposes, it is valuable to appreciate covert behaviors. First, they are observable, namely by the individuals themselves (and this observation can be further enhanced by e.g., practicing mindfulness). Second, they are also often part of learning goals to be developed in the form of knowledge, values, and attitudes. Third, they are behaviors that can be explored similar to overt behaviors in terms of their origins, diversity, and flexibility with the help of the concepts of behavioral sciences. We argue that allowing learners to observe their own feelings, thoughts, values, and attitudes and inquire about their causes and functions or consequences enables learners to be open to and metacognitively self-direct the development of these inner behaviors (see also–Noticing Tool below).

Thus, Ariew and Panchanathan [115] argue that in order to make Tinbergen's questions tenable for the human behavioral and social sciences, the role of agency, including goals, values etc., should and can be included in all four of Tinbergen's questions. For example, Tinbergen's original question concerning the "survival value" of a behavior is overly concerned with biological fitness. When taking an agency approach, the "value" or significance of a behavior can instead be expanded to a broader notion of flourishing. We find that this is also a valuable addition for our purposes, since this question asks students to inquire about the degree to which a behavior might serve (or have served in the past) human values and wellbeing (rather than mere biological fitness in terms of survival and reproduction).

In our formulation of Tinbergen's questions as a thinking tool and organizer of learning content (Figure 3), we were inspired by the above authors and have organized them along a time dimension, with the question about function being applicable across various points in time.

Overall, when it comes to explaining the causes of human behavior, students–and humans in general–may have various intuitive answers. However, our intuitive thinking about causes of human behavior might be quite constrained to a few causal concepts that usually do not include evolutionary explanations (e.g., [116]). In this regard, some psychologists and educators also suggest and provide preliminary evidence that teaching students (or patients in the case of clinical settings) about the evolutionary causes of certain behaviors and related health issues can increase their motivation to engage in healthy behavior, possibly because prescriptions of certain behavioral changes seem less arbitrary [117,118]. As Sherry ([118], p. 8) highlights, "an understanding of evolutionary logic might translate readily into a form of self-empowerment, one that supersedes the authoritarian prescripts that often accompany lectures on health and nutrition for youth." Nettle et al. [119] also found that humans tended to regard biological, psychological and social causal explanations of behaviors as incompatible with, rather than complementary to, each other. People's views on causes of behavior may be influenced by cultural conceptions such as genetic influence, personality, upbringing, and by cognitive biases such as attribution error, and might thus lead to incomplete, or even distorted and unhelpful, views about how and why humans behave the way they do in particular situations [26,99]. As highlighted above, such mindsets and mental models may in turn influence the decisions we make and the actions we engage in.

Tinbergen's questions help students and teachers in expanding, reflecting on, sorting, and further investigating the complex causality of (human) behavior and other phenomena in biology and society, and in seeing that biological, psychological, social-cultural or proximate explanations need not be incompatible but can complement each other and might be variously useful in a particular context. The focus on questions, rather than necessarily "correct" of "complete" answers, also makes Tinbergen's questions an organizer that allows for a holistic and pluralistic perspective on human behaviors. Content across content anchors, or perspectives of different disciplines, can be consulted to help students and teachers to further explore these different causes of our behaviors, while learning about the methods of (behavioral) sciences. For example, cross-species behavioral experiments and observations can be integrated in the biology classroom and help us understand the evolutionary origins and common descent of some human behavioral tendencies. Cross-cultural and developmental psychology experiments and observations could be integrated in the social studies classes and can help us understand the cultural-historic and developmental causes of human behaviors. Behavioral economic experiments and classroom cooperation games can be integrated in the economics classroom and help us understand the role of immediate factors in affecting human behavior and decision making in social interactions.

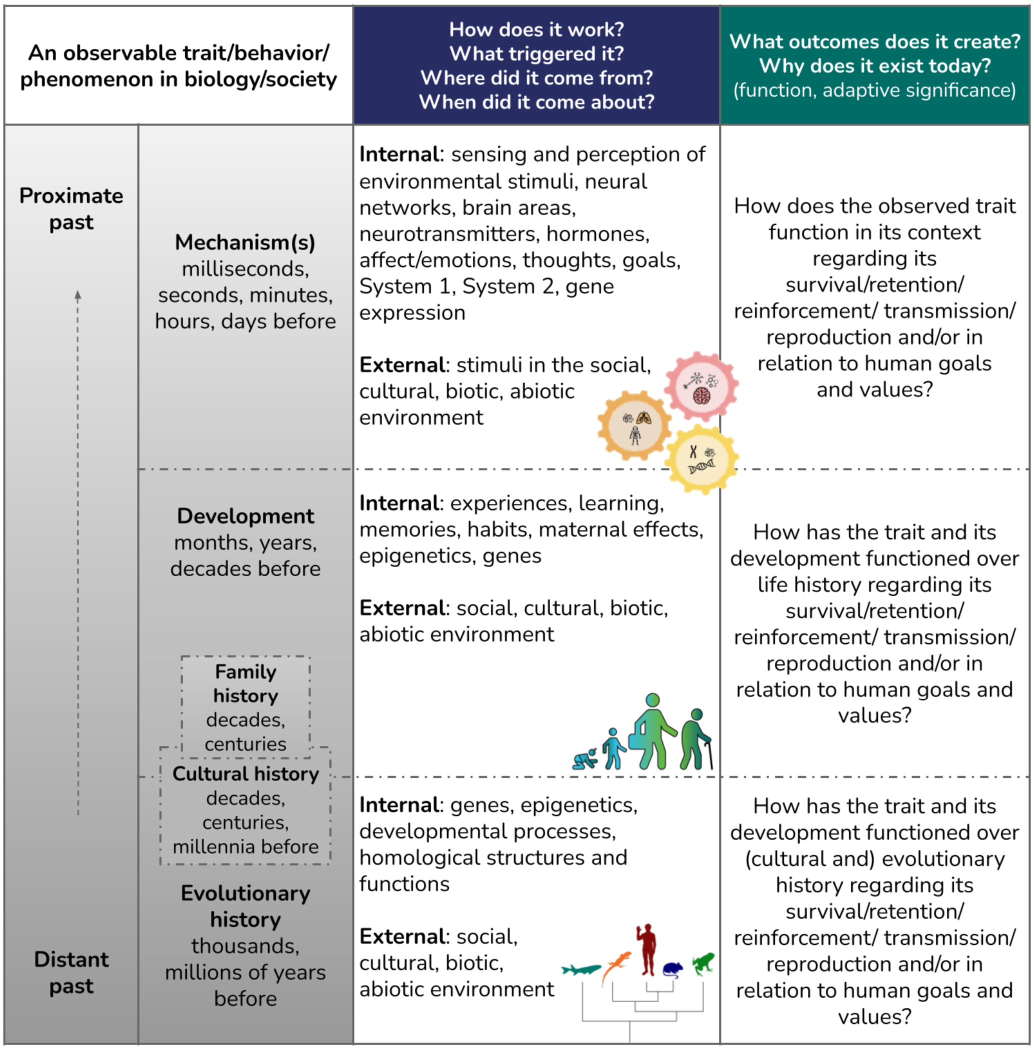


Figure 3. Tinbergen's questions as a thinking tool or advanced organizer to explore various causes of human behavior.

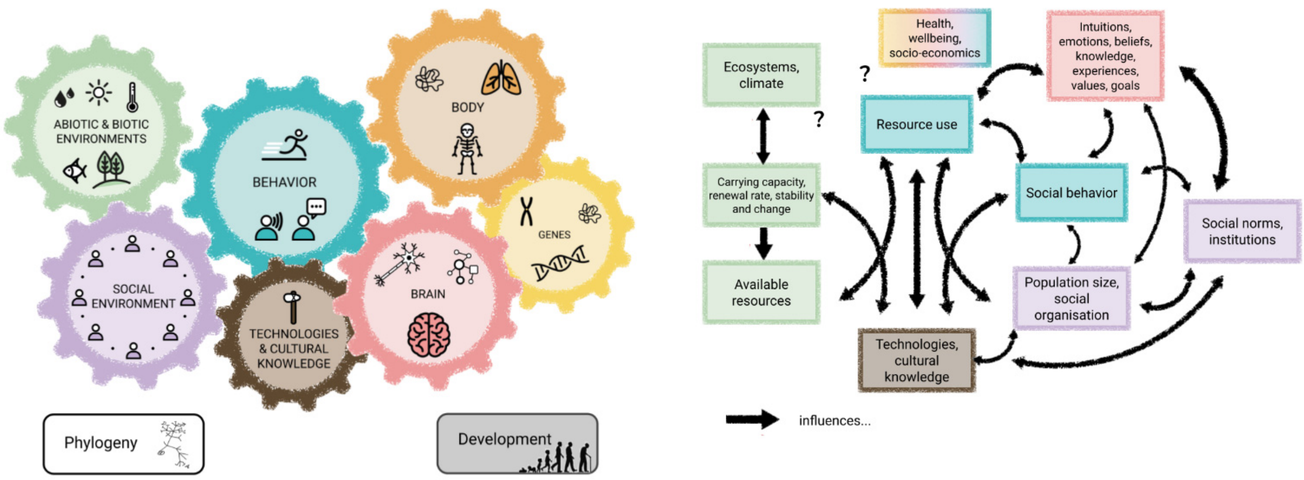
4.4.2. Causal Mapping

Organisms, populations, ecosystems, and societies are complex evolving systems whose dynamics of change cannot be understood solely by breaking them down into isolated parts and linear cause-effect relationships. Systems thinking is thus also an important competency to be developed in ESD and in science education (e.g., [37,120]).

Complex systems are marked by complex systems dynamics, including decentralized causality (there is no central agent in control), non-linear cause-effect relationships such as feedback loops, and emergent properties that cannot be explained by the sum of the system's parts [121]. Importantly for the purpose of this paper, human behaviors and cultures also emerge from complex systems dynamics. For example, the process of learning through reinforcement is a typical reinforcing feedback mechanism, helping to explain how habits can be difficult to break and once established, can be rather effortless to maintain [49].

The spread of certain behaviors, innovations, or social norms in a population is also marked by the interaction of positive and negative feedback loops ([122,123]. These are often influenced by the workings of various social transmission mechanisms including teaching, so-called imitation biases that humans tend to exhibit, such as imitating the majority, the most prestigious, the most successful or the most experienced [124], and a norm psychology [89].

Understanding complex systems dynamics often goes against our intuitive understanding of causality [121]. Developing systems thinking competence thus requires teaching tools that can help students make sense of this complex causality across contexts. In line with many others (e.g., [125,126]), we have integrated in our design concept causal maps, or causal diagrams, as an effective, low-resource, and versatile teaching tool to visualize, discuss, and reflect on complex causal relationships across contexts, including in the evolution and development of human behavior and social-ecological systems. To allow a transdisciplinary view of causality that helps take into account many factors but that at the same time allows to see a deeper structure that is graspable by students, we have developed a set of causal domains that serve as conceptual categories or "coat hangers" for types of causes–genes, body, brain, behavior, social environment, abiotic & biotic environment, technologies & culture (Figure 4a). Dimensions of time and levels on which change happens, such as phylogeny and development as they are also integrated in Tinbergen's questions, can also be made explicit and considered during the elaboration of causal maps.



(a) (b)

Figure 4. (**a**) Causal domains as conceptual structures to help students notice and analyze the causal relationships in evolving social-ecological systems; (**b**) A causal map of a social-ecological system integrating concepts from a range of disciplines. For each link or set of links, concrete studies and observations can be explored to elucidate and discuss the nature of the causal relationship and ways that we might be able to influence this relationship towards outcomes we might care about. Colors represent categories of causal domains.

In Hanisch & Eirdosh [127] we present our causal mapping approach in the context of evolution education with a focus on integrating the role of organism behavior in evolutionary trajectories. With the view that social-ecological systems also evolve through complex interactions between various factors [7], causal diagrams can equally be an effective teaching tool to explore themes of sustainable development, such as the interactions between human behavior, cognition and culture, characteristics of social organization such as norms, population size, and equality, the state of resources and ecosystems, and human health and well-being (Figure 4b).

4.4.3. Payoff Matrix

Many situations in our everyday experience are social interactions–our behaviors not only have effects on ourselves but on others around us, and likewise, other people's behavior has not just effects on them but also on us. Thus, social interactions can lead to emergent outcomes that are more than the sum of their isolated parts, a phenomenon of complex systems dynamics.

Evolutionary biologists, behavioral scientists, and sustainability scientists use a so-called payoff matrix to elucidate these dynamics of social interactions by representing the combinations of costs and benefits that people (or other living beings) get from a behavior in certain contexts (e.g., [128,129]; Figure 5). While the term "payoff" indicates its origin in the field of game theory and might be thought of as limited to monetary values (and in evolutionary biology, this payoff is often meant to represent costs and benefits to evolutionary fitness), for the purposes of sustainability education, "payoff" can also mean any outcome of interest, including outcomes related to human needs, goals, values, general well-being, or social, economic, ecological sustainability, besides economic costs and benefits.

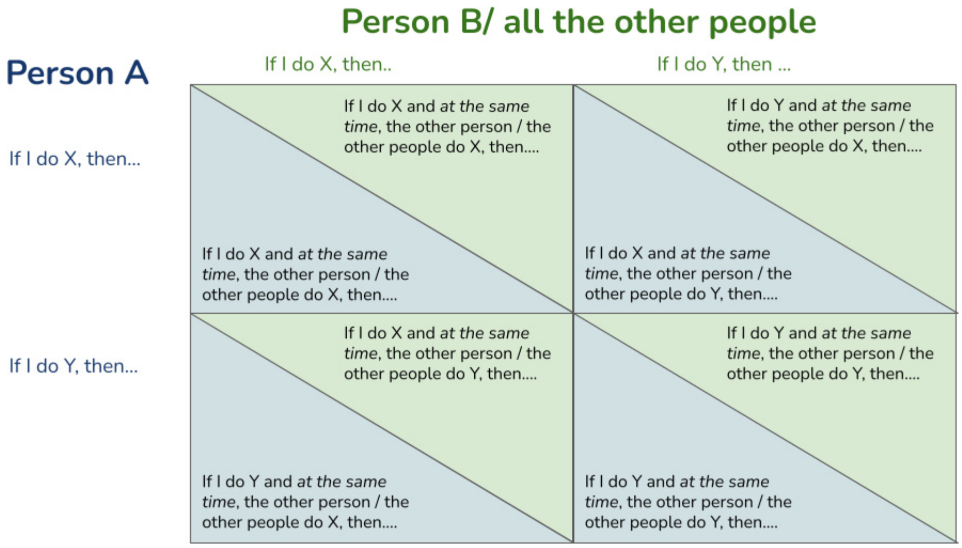


Figure 5. The structure of a payoff matrix. It usually simplifies a situation by identifying two alternative behaviors or strategies that an individual or group might engage in a particular situation. The outcomes in terms of costs and benefits for each combination of behaviors are then analyzed.

Importantly, payoff matrices also help to identify whether there is a social dilemma between what individuals are motivated to do in the short-term and what is best for the community in the long-term. As highlighted above, social dilemmas seem to be at the heart of sustainability challenges, from climate change, to fighting a pandemic, to social and economic equality.

In a similar vein, payoff matrices and the concept of social dilemma help students to inquire about the challenges of cooperation across diverse contexts as well as about the kinds of conditions that we need to create to evolve cooperation towards sustainable development in the various groups we are a part of. Payoff matrices also help students understand how human behaviors can create consequences that nobody intended, thus fostering their systems thinking competencies in relation to explaining and finding solutions to societal issues. Since social dilemmas are all around us, payoff matrices can be introduced and used as a thinking tool for understanding many kinds of situations, from participation in student project groups and shared school spaces, to deforestation, to behavior during a pandemic or in relation to antibiotic resistance.

Importantly, sustainability scientists explore how we can solve such dilemmas by finding ways to align the interests of individuals with the interests of the whole group, or aligning short-term interest with long-term interest (e.g., [129,130]). For example, nudging is a method to induce people to behave in ways that are better for themselves and others in the long-term without resorting to threats, moral appeals or monetary incentives [63]. Others have criticized the targeting of individual-level behaviors [30] and have pointed out the need to intervene and innovate at the systemic level, i.e., by changing the structure or the "rules of the game". Similarly, complexity scientists regard such changing of system structure and rules as among the higher leverage points for system change [62]. One methodology that seeks to align individual and collective interests on a more structural level is the ProSocial approach [72]. Through a set of core design principles, a community is supported in deliberately identifying shared goals, values, and future visions, and in the iterative process of creating and testing rules and norms that allow a community to continuously move towards valued outcomes through aspects such as ensuring fairness, transparency, shared decision making, and appropriate feedback. Such approaches can provide valuable metacognitive strategies to help students develop cooperation and collective action competency.

4.4.4. Noticing Tool

The Noticing Tool is based on a behavioral therapeutic method developed within the field of CBS, and more specifically within a mental health and well-being intervention framework called Acceptance & Commitment Therapy (ACT), where it is often called the ACT Matrix [131] (Figure 6). It is a method used with humans of various ages including children and youth (e.g., [132]).

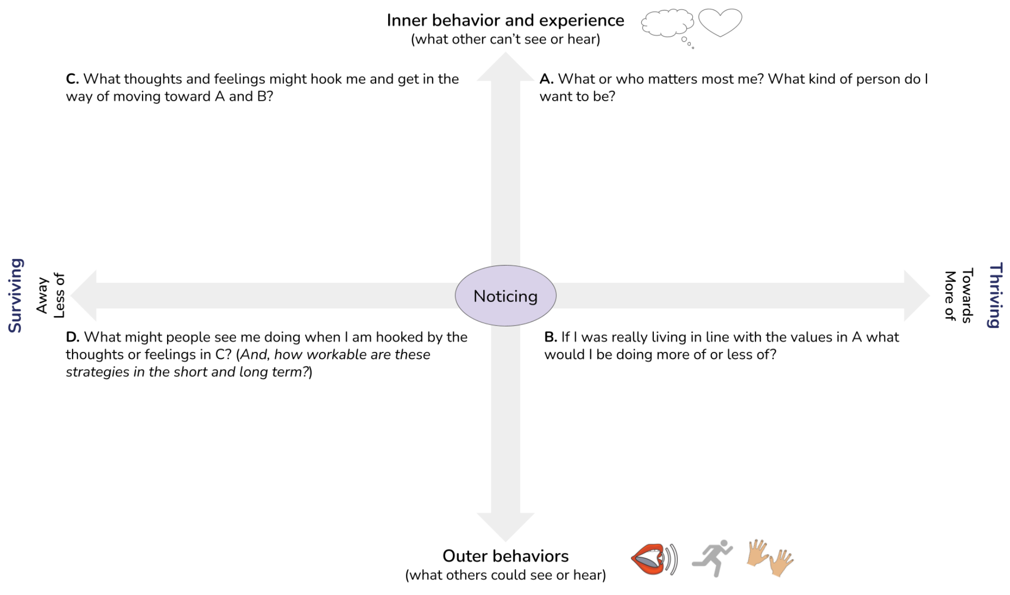


Figure 6. The Noticing Tool with the two dimensions of "inner behavior" and "outer behavior", and "thriving" and "surviving". Adapted from [72,131].

The Noticing Tool allows learners to practice several processes thought to make up the construct of psychological flexibility. Psychological flexibility is the ability to "change or persist in behavior when doing so serves valued ends" [133]. It includes mindful awareness of the present moment, acceptance of and openness to ongoing (including uncomfortable) experiences, values clarification and committed action. As mentioned above, psychological flexibility informs our conceptualization of adaptive flexibility (see Figure 1).

The Noticing Tool (Figure 6) allows learners to practice these skills by becoming aware of and distinguishing their "inner" and "outer" behaviors, and interpreting their functions–i.e., is my behavior more about avoiding uncomfortable situations and focusing on "survival" (such as our reactions to feelings of fear, doubt, stress, guilt, or uncertainty), or is it more motivated by my values and in the service of thriving? As such, the Noticing Tool provides an interesting complementary thinking tool to Tinbergen's questions, allowing students to analyze the causes and functions of their own subjective experience and reorienting their behaviors in the present and future. Importantly, noticing one's own experiences, particularly those that show up on the "upper left corner" of the Noticing Tool, serves to practice acceptance of those experiences as part of the normal human condition.

The distinction between the "survival"/avoidance vs. "thriving" functions of behavior is similar to the distinction between extrinsic and intrinsic motivation in self-determination theory [134]. Both contextual behavioral science and self-determination theory point to the role of such intrinsic motivation and of self-identified values in long-term well-being [75]. In this regard, the focus in CBS on psychological flexibility processes and values clarification can be of particular use in ESD with regard to its aspiration to go beyond socialization and transmission of specific "right" behaviors, towards greater empowerment of learners to identify their own "right", i.e., values-congruent actions [38]. From the perspective of CBS, values are conceptualized as "freely chosen aspects or qualities relating to what is important for the person and guiding their behavioral choices" [5]. Numerous studies have shown that allowing students to reflect on their values in relation to school through simple reflection activities enhances their motivation and academic performance, and that such effects are particularly pronounced for disadvantaged student groups who may be exposed to negative stereotypes and other factors that lower their confidence [135–138]. Relevant for the context of ESD, Stapleton et al. [5] highlight that pro-environmental behavior change efforts are more likely to be enacted and sustained when they are linked to people's values. Importantly, the authors also highlight that "unfortunately, it is common for individuals to lose their valued directions and become confused about what it is that is of meaning to them when living in societies that promote consumerism and overconsumption" [5] (p. 10). In this regard, regular identification and reflection on one's values and the practice of other elements of psychological flexibility can be important components in ESD towards the development of action competence: Sass et al. [38] propose that action competence involves students' willingness and commitment to engage in certain behaviors, as well as confidence and a sense of self-efficacy that they can successfully and effectively use their skills. In the face of conflicting goals, norms, and messages that learners might be exposed to in their social-cultural environments, an explicit focus on values, acceptance, and committed action might serve to enhance students' willingness and sense of self efficacy.

Furthermore, research shows that self-affirmation through reflection on one's values can increase open-mindedness and intellectual humility in debate on controversial topics [139]. Given that intellectual humility entails an awareness and acceptance of one's own ignorance and fallibility [140], this attitude might generally be enhanced by practicing psychological flexibility. Atkins et al. [72] have also expanded the use of the Noticing Tool/ACT Matrix for the context of groups, allowing group members to share and communicate their values as well as concerns, thus fostering trust and a sense of common humanity and shared identity, while allowing groups to consider new norms and behaviors that are congruent with their values. In this way, these methods can also be helpful in developing students' cooperation, communication, and action competence related to collective action.

We thus propose that the Noticing Tool and similar methods informed by CBS to support psychological flexibility (e.g., the DNA-V model developed for younger people, [141]) can be productively used in ESD for the development of a number of competencies, particularly self-regulation, evaluation, cooperation, critical thinking, and competence for individual and collective action, as well as attitudes such as intellectual humility, empathy, a sense of common humanity, and growth mindset. Importantly, this social-emotional learning with the help of the Noticing Tool can be supported by cognitive learning about human behavioral concepts such as emotions, language, and values, and exploring their causes and functions in human behavior and well-being.

4.4.5. Analogy Mapping

Another thinking tool we present here helps to transfer processes and principles of human behaviors across contexts, and thus is a core tool to help implement our third overarching principle–teach for transfer of learning.

Analogy maps are one way to help think clearly about the transferability of overarching principles across contexts that might have quite different surface features. In analogy maps, two or more phenomena are compared based on underlying concepts, processes or principles [142]. Thus, within our design concept, analogy maps can be used to help students compare, for example, different situations of common pool resource use by underlying conditions and principles, different human behaviors by their causes as described in Tinbergen's questions, or genetic, cultural and cognitive-behavioral evolution by generalizable evolutionary processes. For example, in Hanisch et al. [143] we present a unit to help students understand the conditions that foster cooperation and sustainable resource management, based on the work of Elinor Ostrom [7,101,144] (Table 1). With the help of analogy maps, students can critically transfer these conditions to diverse contexts, such as cooperation games, computer simulations, real-world case studies, cooperation dynamics in other biological species, behavioral experiments, their own student project group, or global climate change.

Table 1. An analogy map with design principles for cooperation (based on [72,144]), and for students to critically transfer these principles to various contexts. Adapted from [143].

Design Principle	Our Project Group	Our School Community	Global Climate Change	Analogous Biological Examples
1. Shared goals and identity				Skin and cell membranes; fitness interdependence through factors such as physical proximity and low levels of migration, positive assortment and genetic relatedness
2. Fair distribution of costs and benefits				Need-based transfer of resources (e.g., vampire bats, trophallaxis in social insects, nutrient distribution in multicellular organisms)
3. Fair and inclusive decision making				Quorum sensing in bacteria, decision making for nesting sites in honeybee swarms
4. Transparency and monitoring				Policing in insect societies; the immune systems in animal bodies
5. Graduated responses to helpful and unhelpful behaviors				
6. Fast and fair conflict resolution				
7. Autonomy to self-govern				Becomes relevant when higher levels of selection emerge (e.g., endosymbiosis, multicellular organisms, symbiosis and major transitions in evolution)
8. Cooperative relations with other groups				

4.4.6. Structure of Knowledge Diagrams

A final thinking tool we have developed to enable metacognitive competency is the Structure of Knowledge diagram (Figure 7). Building on the work of educators in conceptual learning [17,85], we suggest students can benefit from this specific model of concept mapping, in which facts are organized within topics or contexts, which are understood through concepts, theories, principles, and generalizations.

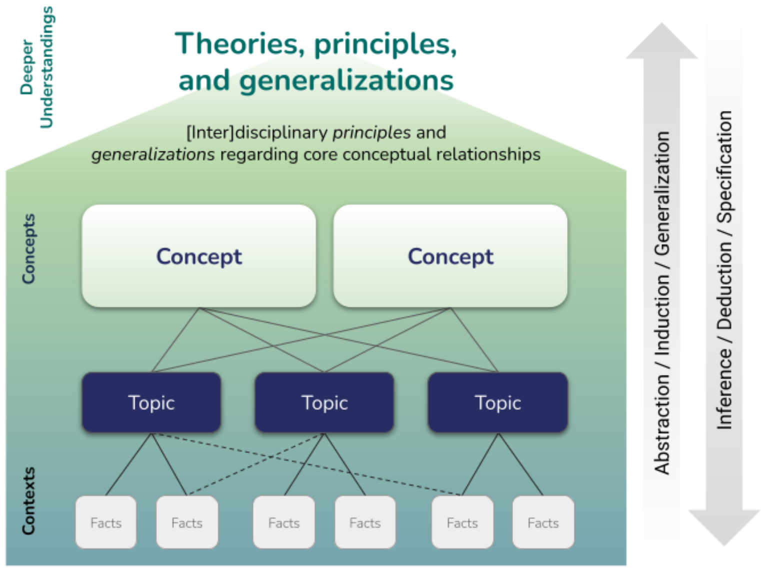


Figure 7. A generalized Structure of Knowledge diagram (adapted from [17,85]).

This approach may drive metacognitive competency by offering students explicit and visual representations of core cognitive processes underlying conceptual development and learning. The relation of facts about the world to abstract, explanatory concepts and conceptual networks represents a deep principle and transferable model of cognitive systems that can also serve as a practical tool for reflecting on the conceptual structures of scientific theories, and even school curricula. This is because analogical reasoning, relating facts through concepts, is at the core of human thinking [145] and cultural evolution [146]. It is through processes of comparing and contrasting the diversity of phenomena in our lives, that we learn and develop our own internal structures of knowledge, more implicitly or explicitly, depending on the metacognitive influences of our environments. By engaging students (and teachers) in reflecting on actual or possible structures of knowledge among individuals, communities, or cultures, learners are empowered with a new tool to understand and adapt the deeper worldviews that shape sustainability dilemmas.

For all the reasons discussed so far, human behavioral science, and the interdisciplinary concepts relevant to understanding human behavior offer a particularly rich landscape for reflecting and shaping explicit structures of knowledge (among individuals and communities), as relevant to the design of a more interdisciplinary and action-oriented sustainability curriculum. Figure 8 maps just a few example disciplines, core concepts, and sustainability contexts that schools could focus on to drive conceptual metacognition and valued learning environments. As part of participatory curriculum re-design efforts (sensu [82,147]), school stakeholders can be empowered to map and reflect on the disciplinary and interdisciplinary conceptual landscape of their school curriculum. Structure of Knowledge diagrams can play a central role in such on-going discussions.

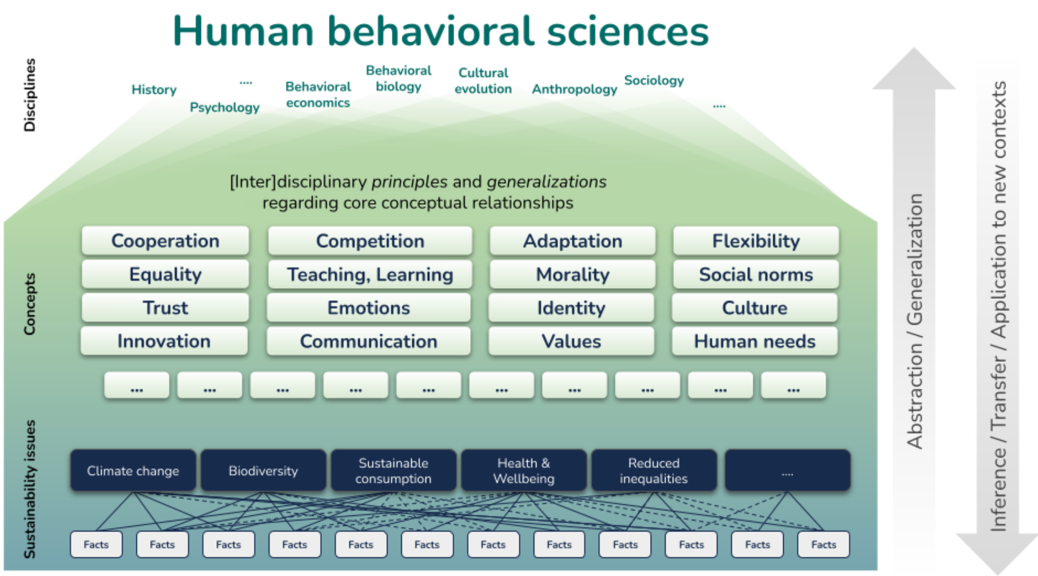


Figure 8. A Structure of Knowledge diagram relating diverse behavioral sciences to diverse sustainability issues, through variously shared interdisciplinary concepts.

4.5. Pedagogy

As highlighted above, ESD programming tends to favor learner-centered, experiential, active and transformative pedagogical methods. However, we caution that this focus on experiential pedagogical methods should not lead to a “throwing out the baby with the bathwater” in relation to other important pedagogical methods that support students in developing conceptual, transferable understandings.

In the formulation of our design concept, we have therefore found the approach of “multiliteracies” and “reflexive pedagogy” advanced by Cope and Kalantzis [148] particularly helpful and fruitful. These authors highlight that learning involves a number of knowledge processes and associated pedagogical approaches that target these processes, and that good pedagogy involves not the choosing of one pedagogy over another, but the weaving together of all these processes to maximize learning. These knowledge processes and pedagogies include:

- **Experiential learning** approaches that allow students to build on their everyday experience, let them experience known phenomena in a new light, or let them experience new phenomena. Here, the strength of human behavior as an interdisciplinary theme shows itself, since human behaviors are prevalent in students’ everyday experience, which can be brought into the learning experience. Additionally, many experiential methods exist, including classroom cooperation games, which allow students to (re)experience various behaviors directly during a learning sequence.
- **Conceptual learning** approaches that help students construct transferable understandings of concepts and principles. Towards our goal of developing in learners transferable conceptual understanding of human behavior, we build particularly on methods advanced by Stern et al. [17,86], as well as analogies, metaphors, and analogy maps as important tools that foster transfer of overarching concepts and principles across content ([142]; see above). The focus on conceptual learning highlights that student experience of human behavior needs to be reflected on towards the construction of schemas and mental models, which can then be used to make sense of new situations, by noticing how concepts apply and how overarching principles and strategies can be used to analyze the situation.
- **Critical pedagogy** that encourages students to critically analyze and reflect on the learned phenomena. Here we encourage educators to drive student reflection on what the learned means for themselves and for sustainable development. Learning about

human behavioral science might be regarded as an end in itself in line with the goals of science education. In relation to ESD and in our design concept however, learning about human behavior is more a means to an end–the end of developing metacognitive competency and associated competencies and attitudes. How does our understanding of human behavioral dimensions relate to creating a better life for ourselves and a better world, what obstacles and solutions does this understanding help us identify? Additionally, critical reflection is required given the complex and pluralistic nature of human behavioral science as highlighted above, allowing students to inquire about the generalizability, ethics, and effectiveness of behavioral science methods and insights. Finally, critical reflection is required in relation to human behavior given the fact that behaviors might be adaptive or functional in the short-term or on the level of the individual, but not in the long-term or on the collective level, or might have been adaptive in the past but might not anymore be adaptive or serving human values today. Thinking tools like payoff matrices and the Noticing Tool can be helpful in this respect, as does the concept of evolutionary mismatch [117].

- **Transformative pedagogy** that encourages students to apply their learning to real-world problems. Ultimately, a conceptual understanding of human behavior is meant to serve the purpose of helping students notice, reorient, and evaluate their own behaviors and the collective behaviors of the groups they are a part of. Towards this aim, we also develop within our design concept various project materials and supports that help students implement behavioral science concepts and methods, both in their own individual lives as well as for shaping their communities. For example, we have advanced Community Science as an approach to participatory school improvement that involves students as leaders and researchers of their school culture [149].

5. Applying the Design Concept in Educational Settings

Our emphasis on human behavior and our focus on the behavioral dimensions of sustainability problems is not meant to replace educational approaches that help students understand the ecological, economic, technical, or social dimensions of these issues and possible solutions. Rather, we aim to draw educators' and students' attention to the fact that such phenomena entail human behavioral dimensions which need to be explored in their own right and in complementarity to other perspectives. Furthermore, the strength of the behavioral lens lies in the fact that human behaviors are close to every students' everyday experience, allowing connections to be made between potentially abstract sustainability issues and students' own lives, and allowing experiential learning methods to be leveraged to the fullest.

Depending on the educational context, including curriculum structure, and learning goals, there may be numerous ways that our design concept might serve educators in the design of curricula and learning environments. As mentioned above, human behavioral concepts might be situated in various places in existing curricula. Here we formulate questions, informed by the structure of our design concept, to help educators see their local curriculum through a behavioral lens and to help them and their students see "the forest for the trees" when it comes to drawing from the diverse subject areas towards a well-rounded understanding of, or a well-rounded set of tools from which to reflect on, human behavior. In general, we suggest and draw on the approaches by [85,86] regarding the reorientation of curriculum and design of learning sequences around core disciplinary and interdisciplinary concepts, in this case, around human behavioral concepts.

Focus on human behavior

- Where in your local curriculum across subjects are human behavioral concepts covered?
    - For example, where does your curriculum contain learning about cooperation and prosociality, well-being, social norms, culture, language, values and how can subjects be connected into interdisciplinary learning opportunities?

- What is the learning goal in relation to this content? In particular, does it involve developing in students conceptual understanding of these behavioral concepts by exploring behaviors from multiple subject-area perspectives?
- How can these behavioral concepts be connected to student experience and to diverse sustainability issues?

Explore the complex causes of human behavior

- Do students in your educational context have the opportunity to acquire knowledge about and to reflect on the complex causes of these behaviors?
- How can subject-area perspectives be leveraged for the exploration of the complex causes and consequences of behavior? For example:
  - If behavioral biology is a topic in your curriculum, is there opportunity for students to transfer understandings of animal behavior to human behavioral dimensions, particularly those relevant to well-being, sustainability, and to important competencies?
  - If human evolution is a topic in the biology curriculum, is there opportunity for students to explore the evolutionary origins of sustainability-relevant behaviors such as prosociality, morality, teaching, and learning ([150])?
  - If computer science or math curricula contain working with computer simulations, is there opportunity for students to explore agent-based models of social-ecological systems?
  - Does your economics curriculum contain learning about social interactions, social dilemmas, or the payoff matrix? How can these concepts be linked to phenomena studied in other subjects, such as in geography or biology?
  - Do students in your educational context have the opportunity to explore cross-cultural research regarding the diversity and flexibility of social norms and the way they affect our beliefs and behaviors? If not, where in the curriculum might such learning opportunities be productively integrated?

Teach for transfer of learning

- Do students in your educational context have the opportunity to transfer and apply their understandings of human behaviors to their everyday lives and towards individual and collective behavior change, including to the participatory improvement of their school?
- Where in your curriculum structure might such learning opportunities be productively integrated (e.g., project days or weeks, student internships and capstone projects, student after school clubs, etc.)?

6. Conclusions

We have argued in this article that there is potential for ESD to more centrally integrate behavioral science into curriculum design towards the development of students' metacognitive competencies, which in turn underlies and supports the development of numerous other competencies and attitudes, such as self-regulation, cooperation, critical thinking, and action competence. Based on our design concept, we continue to develop, implement, and evaluate numerous teaching materials as well as teacher education curricula within an educational design research framework [151,152] in order to further investigate this potential and refine our design concept. For example, we have been developing a pre-service teacher education module on human behavior and sustainable development which uses our design-concept as an explicit thread. In Hanisch & Tempelmann (in review), we highlight preliminary evidence about the learning potential and competency development of pre-service teachers that is afforded by this module design. Current and future research on the module design and implementation involves investigating the role of digital and self-directed learning in student motivation and learning outcomes, and an evaluation of how the module design impacts participants' competency development, including their action competence, through specific assignments for real-world application and reflection of behavioral concepts and tools. Further educational design work is ongoing in cooperation with teachers internationally around selected behavioral themes and tools as part of, e.g., the biology or ethics classroom or as part of participatory school improvement efforts.

We realize that given the current structure of education systems and the multiple demands placed on education and educators in the face of increasing curriculum overload, it can be a challenge to exploit this potential. In line with a proposal by [81] regarding the integration of behavioral science in US curricula, rather than demanding that behavioral science be added to the existing curriculum, our design concept is meant to offer guidance for educators to reinterpret their curriculum through the lens of behavioral science and to help students develop deeper understandings about what it means to be human in today's world. However, in the long-term, we also hope that our design concept can inform or inspire curriculum reform towards a focus on human behavior as a central interdisciplinary theme due to its connection to a diversity of educational goals.

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References

1. Biglan, A. *The Nurture Effect—How the Science of Human Behavior Can Improve Our Lives & Our World*; New Harbinger Publications: Oakland, CA, USA, 2015; ISBN 978-1-60882-956-9.
2. Fisher, E.B.; Fitzgibbon, M.L.; Glasgow, R.E.; Haire-Joshu, D.; Hayman, L.L.; Kaplan, R.M.; Nanney, M.S.; Ockene, J.K. Behavior Matters. *Am. J. Prev. Med.* **2011**, *40*, e15–e30. [CrossRef]
3. Van Bavel, J.J.; Baicker, K.; Boggio, P.S.; Capraro, V.; Cichocka, A.; Cikara, M.; Crockett, M.J.; Crum, A.J.; Douglas, K.M.; Druckman, J.N.; et al. Using Social and Behavioural Science to Support COVID-19 Pandemic Response. *Nat. Hum. Behav.* **2020**, *4*, 460–471. [CrossRef] [PubMed]
4. Gifford, R.; Nilsson, A. Personal and Social Factors That Influence Pro-Environmental Concern and Behaviour: A Review. *Int. J. Psychol.* **2014**, *49*, 141–157. [CrossRef] [PubMed]
5. Stapleton, A.; McHugh, L.; Karekla, M. How to Effectively Promote Eco-Friendly Behaviors: Insights from Contextual Behavioral Science. *Sustainability* **2022**, *14*, 13887. [CrossRef]
6. Cialdini, R.B. Crafting Normative Messages to Protect the Environment. *Psychol. Sci.* **2003**, *12*, 105–109. [CrossRef]
7. Ostrom, E. A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science* **2009**, *325*, 419–422. [CrossRef] [PubMed]
8. Messner, D.; Guarín, A.; Haun, D.B.M. *The Behavioural Dimensions of International Cooperation*; Centre for Global Cooperation Research: Duisburg, Germany, 2013.
9. Alavosius, M.; Newsome, D.; Houmanfar, R.; Biglan, A. A Functional Contextualist Analysis of the Behavior and Organizational Practices Relevant to Climate Change. In *The Wiley Handbook of Contextual Behavioral Science*; Zettle, R.D., Hayes, S.C., Barnes-Holmes, D., Biglan, A., Eds.; Wiley & Sons: Hoboken, NJ, USA, 2015; pp. 513–530; ISBN 978-1-118-48985-7.
10. Gifford, R.; Kormos, C.; McIntyre, A. Behavioral Dimensions of Climate Change: Drivers, Responses, Barriers, and Interventions. *WIREs Clim. Chang.* **2011**, *2*, 801–827. [CrossRef]
11. Haidt, J. *The Righteous Mind: Why Good People Are Divided by Politics and Religion*; Pantheon Books: New York, NY, USA, 2012.
12. Lilienfeld, S.O.; Ammirati, R.; Landfield, K. Giving Debiasing Away. Can Psychological Research on Correcting Cognitive Errors Promote Human Welfare? *Perspect. Psychol. Sci.* **2009**, *4*, 390–398. [CrossRef]
13. UN. *Practitioner's Guide to Getting Started with Behavioural Science. Applications to UN Policies, Programmes and Administration*; UN Innovation Network: New York, NY, USA, 2022. Available online: https://www.uninnovation.network/assets/BeSci/UN_PractitionersGuideToGettingStartedWithBeSci_2022.pdf (accessed on 13 March 2023).
14. Schimmelpfennig, R.; Muthukrishna, M. Cultural Evolutionary Behavioural Science in Public Policy. *Behav. Public Policy* **2023**, 1–31. [CrossRef]
15. UNESCO. *Education for Sustainable Development: A Roadmap*; UNESCO: Paris, France, 2020.

16. Sinakou, E.; Donche, V.; Boeve-de Pauw, J.; Van Petegem, P. Designing Powerful Learning Environments in Education for Sustainable Development: A Conceptual Framework. *Sustainability* **2019**, *11*, 5994. [CrossRef]
17. Stern, J.; Ferraro, K.; Mohnkern, J. *Tools for Teaching Conceptual Understanding, Secondary—Designing Lessons and Assessments for Deep Learning*; Corwin: Thousand Oaks, CA, USA, 2017; ISBN 978-1-5063-5570-2.
18. Gintis, H. *The Bounds of Reason. Game Theory and the Unification of the Behavioral Sciences*; Princeton University Press: Princeton, NJ, USA; Oxford, UK, 2009; ISBN 978-0-691-14052-0.
19. Levitis, D.A.; Lidicker, W.Z.; Freund, G. Behavioural Biologists Do Not Agree on What Constitutes Behaviour. *Anim. Behav.* **2009**, *78*, 103–110. [CrossRef] [PubMed]
20. Bryan, C.J.; Tipton, E.; Yeager, D.S. Behavioural Science Is Unlikely to Change the World without a Heterogeneity Revolution. *Nat. Hum. Behav.* **2021**, *5*, 980–989. [CrossRef] [PubMed]
21. Henrich, J.; Heine, S.J.; Norenzayan, A. The Weirdest People in the World? *Behav. Brain Sci.* **2010**, *33*, 61–83; discussion 83–135. [CrossRef]
22. Apicella, C.; Norenzayan, A.; Henrich, J. Beyond WEIRD: A Review of the Last Decade and a Look ahead to the Global Laboratory of the Future. *Evol. Hum. Behav.* **2020**, *41*, 319–329. [CrossRef]
23. Gintis, H. A Framework for the Unification of the Behavioral Sciences. *Behav. Brain Sci.* **2007**, *30*, 1–16; discussion 16–61. [CrossRef] [PubMed]
24. Mesoudi, A. *Cultural Evolution: How Darwinian Theory Can Explain Human Culture and Synthesize the Social Sciences*; University of Chicago Press: Chicago, IL, USA, 2011; ISBN 978-0-226-52044-5.
25. Boyd, R.T.; Richerson, P.J. *The Origin and Evolution of Cultures*; Evolution and Cognition; Oxford University Press: Oxford, UK, 2005; ISBN 978-0-19-516524-1.
26. Tavoni, A.; Levin, S. Managing the Climate Commons at the Nexus of Ecology, Behaviour and Economics. *Nat. Clim. Chang.* **2014**, *4*, 1057–1063. [CrossRef]
27. Henrich, J.; Boyd, R.T.; Bowles, S.; Camerer, C.F.; Fehr, E.; Gintis, H.; McElreath, R. In Search of Homo Economicus: Behavioral Experiments in 15 Small Scale Societies. *Am. Econ. Rev.* **2001**, *91*, 73–78. [CrossRef]
28. Bowles, S. Policies Designed for Self-Interested Citizens May Undermine "the Moral Sentiments": Evidence from Economic Experiments. *Science* **2008**, *320*, 1605–1609. [CrossRef]
29. Moya, C.; Cruz, P.; Kline, M.A.; Smaldino, P.E. Dynamics of Behavior Change in the COVID World. *Am. J. Hum. Biol.* **2020**, *32*, e23485. [CrossRef]
30. Chater, N.; Loewenstein, G. The I-Frame and the s-Frame: How Focusing on Individual-Level Solutions Has Led Behavioral Public Policy Astray. *Behav. Brain Sci.* **2022**, 1–60. [CrossRef]
31. Ciarrochi, J.; Atkins, P.W.B.; Hayes, L.L.; Sahdra, B.K.; Parker, P. Contextual Positive Psychology: Policy Recommendations for Implementing Positive Psychology into Schools. *Front. Psychol.* **2016**, *7*, 1561. [CrossRef] [PubMed]
32. Van Bouwel, J.; Weber, E. A Pragmatist Defense of Non-Relativistic Explanatory Pluralism in History and Social Science. *Hist. Theory* **2008**, *47*, 168–182. [CrossRef]
33. Hanisch, S.; Eirdosh, D. Teaching for the Interdisciplinary Understanding of Evolutionary Concepts. In *Evolutionary Thinking Across Disciplines—Problems and Perspectives in Generalized Darwinism*; du Crest, A., Valković, M., Ariew, A., Desmond, H., Huneman, P., Reydon, T., Eds.; Springer: Cham, Switzerland, 2023; ISBN 978-3-031-33357-6.
34. UNESCO. *Roadmap for Implementing the Global Action Programme on Education for Sustainable Development*; UNESCO: Paris, France, 2014.
35. de Haan, G. The BLK '21' Programme in Germany: A 'Gestaltungskompetenz'-based Model for Education for Sustainable Development. *Environ. Educ. Res.* **2006**, *12*, 19–32. [CrossRef]
36. UNESCO. *Education for Sustainable Development Goals Learning Objectives*; UNESCO: Paris, France, 2017; ISBN 978-92-3-100209-0.
37. Redman, A.; Wiek, A. Competencies for Advancing Transformations Towards Sustainability. *Front. Educ.* **2021**, *6*, 785163. [CrossRef]
38. Sass, W.; Boeve-de Pauw, J.; Olsson, D.; Gericke, N.; De Maeyer, S.; Van Petegem, P. Redefining Action Competence: The Case of Sustainable Development. *J. Environ. Educ.* **2020**, *51*, 292–305. [CrossRef]
39. Boyes, E.; Stanisstreet, M. Environmental Education for Behaviour Change: Which Actions Should Be Targeted? *Int. J. Sci. Educ.* **2012**, *34*, 1591–1614. [CrossRef]
40. Braßler, M.; Sprenger, S. Fostering Sustainability Knowledge, Attitudes, and Behaviours through a Tutor-Supported Interdisciplinary Course in Education for Sustainable Development. *Sustainability* **2021**, *13*, 3494. [CrossRef]
41. Olsson, D.; Gericke, N.; Boeve-de Pauw, J. The Effectiveness of Education for Sustainable Development Revisited—A Longitudinal Study on Secondary Students' Action Competence for Sustainability. *Environ. Educ. Res.* **2022**, *28*, 405–429. [CrossRef]
42. Mercedes Varela-Losada; Pedro Vega-Marcote; Uxío Pérez-Rodríguez; María Álvarez-Lires Going to Action A Literature Review on Educational Proposals in Formal Environmental Educa. *Pdf. Environ. Educ. Res.* **2016**, *22*, 390–421. [CrossRef]
43. Renz, E.; Böhm, K.L. Using Behavioral Economics to Reduce the Value-Action Gap. *Ökologisches Wirtsch. Fachz.* **2020**, *33*, 45–50. [CrossRef]
44. Frick, M.; Neu, L.; Liebhaber, N.; Sperner-Unterweger, B.; Stötter, J.; Keller, L.; Hüfner, K. Why Do We Harm the Environment or Our Personal Health despite Better Knowledge? The Knowledge Action Gap in Healthy and Climate-Friendly Behavior. *Sustainability* **2021**, *13*, 13361. [CrossRef]

45. Kollmuss, A.; Agyeman, J. Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to pro-Environmental Behavior? *Environ. Educ. Res.* **2002**, *8*, 239–260. [CrossRef]
46. Arbuthnott, K.D. Education for Sustainable Development beyond Attitude Change. *Int. J. Sustain. High. Educ.* **2010**, *10*, 152–163. [CrossRef]
47. Heimlich, J.; Ardoin, N.M. Understanding Behavior to Understand Behavior Change: A Literature Review. *Environ. Educ. Res.* **2008**, *4*, 215–237. [CrossRef]
48. Kelly, M.P.; Barker, M. Why Is Changing Health-Related Behaviour so Difficult? *Public Health* **2016**, *136*, 109–116. [CrossRef]
49. Linder, N.; Giusti, M.; Samuelsson, K.; Barthel, S. Pro-Environmental Habits: An Underexplored Research Agenda in Sustainability Science. *Ambio* **2022**, *51*, 546–556. [CrossRef]
50. Toomey, A.H. Why Facts Don't Change Minds: Insights from Cognitive Science for the Improved Communication of Conservation Research. *Biol. Conserv.* **2023**, *278*, 109886. [CrossRef]
51. Simis, M.J.; Madden, H.; Cacciatore, M.A.; Yeo, S.K. The Lure of Rationality: Why Does the Deficit Model Persist in Science Communication? *Public Underst. Sci.* **2016**, *25*, 400–414. [CrossRef]
52. Luetz, J.M.; Margus, R.; Prickett, B. Human Behavior Change for Sustainable Development: Perspectives Informed by Psychology and Neuroscience. In *Quality Education*; Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T., Eds.; Encyclopedia of the UN Sustainable Development Goals; Springer International Publishing: Cham, Switzerland, 2020; pp. 419–434; ISBN 978-3-319-95870-5.
53. Jones, N.A.; Ross, H.; Lynam, T.; Perez, P.; Leitch, A. Mental Models: An Interdisciplinary Synthesis of Theory and Methods. *Ecol. Soc.* **2011**, *16*, 46. [CrossRef]
54. Frank, R.H.; Gilovich, T.; Regan, D.T. Does Studying Economics Inhibit Cooperation? *J. Econ. Perspect.* **1993**, *7*, 159–171. [CrossRef]
55. Gerlach, P. The Games Economists Play: Why Economics Students Behave More Selfishly than Other Students. *PLoS ONE* **2017**, *12*, e0183814. [CrossRef] [PubMed]
56. Wang, L.; Malhotra, D.; Murnighan, J.K. Economics Education and Greed. *Acad. Manag. Learn. Educ.* **2011**, *10*, 643–660. [CrossRef]
57. Alesina, A.; Giuliano, P. Preferences for Redistribution. In *Handbook of Social Economics*; Benhabib, J., Bisin, A., Jackson, M.O., Eds.; North-Holland: Amsterdam, Netherlands, 2011; Volume 1, pp. 93–131.
58. Wilson, T.D. *Redirect: The Surprising New Science of Psychological Change*; Little, Brown and Company: Boston, MA, USA, 2011; ISBN 978-0316051880.
59. Dweck, C.S. Mindsets and Human Nature: Promoting Change in the Middle East, the Schoolyard, the Racial Divide, and Willpower. *Am. Psychol.* **2012**, *67*, 614–622. [CrossRef] [PubMed]
60. McMahan, E.A.; Estes, D. Measuring Lay Conceptions of Well-Being: The Beliefs About Well-Being Scale. *J. Happiness Stud.* **2011**, *12*, 267–287. [CrossRef]
61. McMahan, E.A.; Dixon, K.J.; King, L.M. Evidence of Associations Between Lay Conceptions of Well-Being, Conception-Congruent Behavior, and Experienced Well-Being. *J. Happiness Stud.* **2013**, *14*, 655–671. [CrossRef]
62. Meadows, D. *Leverage Points—Places to Intervene in a System*; Sustainability Institute: Hartland, VT, USA, 1999.
63. Thaler, R.H.; Sunstein, C.R. *Nudge: Improving Decisions about Health, Wealth, and Happiness*; Yale University Press: New Haven, CT, USA, 2008; ISBN 9780300262285.
64. UNEP; GRID Arendal; Behavioural Insights Team. *The Little Book of Green Nudges.40 Nudges to Spark Sustainable Behaviour on Campus*; UNEP: Nairobi, Kenya, 2020; ISBN 978-82-7701-198-1.
65. Monroe, M.C. Two Avenues for Encouraging Conservation Behaviors. *Hum. Ecol. Rev.* **2003**, *10*, 113–125.
66. Wang, X.; Yao, X. Fueling Pro-Environmental Behaviors with Gamification Design: Identifying Key Elements in Ant Forest with the Kano Model. *Sustainability* **2020**, *12*, 2213. [CrossRef]
67. Ouariachi, T.; Li, C.-Y.; Elving, W.J.L. Gamification Approaches for Education and Engagement on Pro-Environmental Behaviors: Searching for Best Practices. *Sustainability* **2020**, *12*, 4565. [CrossRef]
68. Rosa, C.D.; Profice, C.C.; Collado, S. Nature Experiences and Adults' Self-Reported pro-Environmental Behaviors: The Role of Connectedness to Nature and Childhood Nature Experiences. *Front. Psychol.* **2018**, *9*, 1055. [CrossRef]
69. Schraw, G.; Moshman, D. Metacognitive Theories. *Educ. Psychol. Rev.* **1995**, *7*, 351–371. [CrossRef]
70. Schraw, G.; Crippen, K.J.; Hartley, K. Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning. *Res. Sci. Educ.* **2006**, *36*, 111–139. [CrossRef]
71. Conyers, M.; Wilson, D. *Positively Smarter. Science and Strategies for Increasing Happiness, Achievement, and Well-Being*; Wiley-Blackwell: Hoboken, NJ, USA, 2015; ISBN 978-1-118-92609-3.
72. Atkins, P.W.B.; Wilson, D.S.; Hayes, S.C. *Prosocial—Using Evolutionary Science to Build Productive, Equitable, and Collaborative Groups*; Context Press: Oakland, CA, USA, 2019.
73. Halpern, D.F. Teaching Critical Thinking for Transfer across Domains. Disposition, Skills, Structure Training, and Metacognitive Monitoring. *Am. Psychol.* **1998**, *53*, 449–455. [CrossRef] [PubMed]
74. Duong, M.; Welker, K.; Mehl, C. *Turning Down the Heat on Campus: How an Online Educational Program Can Reduce Polarization and Improve Dialogue in College Classrooms*; The Constructive Dialogue Institute: New York, NY, USA, 2022; p. 22.
75. Kashdan, T.B.; Rottenberg, J. Psychological Flexibility as a Fundamental Aspect of Health. *Clin. Psychol. Rev.* **2010**, *30*, 865–878. [CrossRef]

76. Fang, S.; Ding, D. A Meta-Analysis of the Efficacy of Acceptance and Commitment Therapy for Children. *J. Context. Behav. Sci.* **2020**, *15*, 225–234. [CrossRef]
77. Roche, A.I.; Kroska, E.B.; Denburg, N.L. Acceptance- and Mindfulness-Based Interventions for Health Behavior Change: Systematic Reviews and Meta-Analyses. *J. Context. Behav. Sci.* **2019**, *13*, 74–93. [CrossRef] [PubMed]
78. Schreiber, J.-R.; Siege, H. *Curriculum Framework—Education for Sustainable Development*; Engagement Global: Bonn, Germany, 2016.
79. Kim, M.; Diong, C.H. *Biology Education for Social and Sustainable Development*; Kim, M., Diong, C.H., Eds.; Sense Publishers: Rotterdam, The Netherlands, 2012; ISBN 978-94-6091-925-1.
80. Seeber, G.; Birke, F. Using a Fox to Guard the Geese? A German Debate on the Purposes of Economic Education in Relation to Sustainability and the Role of Values. *Citizsh. Soc. Econ. Educ.* **2011**, *10*, 170–181. [CrossRef]
81. *The Social and Behavioral Sciences in K-12 Education: Past, Present, and Future: Proceedings of a Workshopâ in Brief*; National Academies of Sciences, Engineering and Medicine (Ed.) National Academies Press: Washington, DC, USA, 2017; p. 24774; ISBN 978-0-309-45933-4.
82. OECD. *Curriculum Overload. A Way Forward*; OECD: Paris, France, 2020.
83. Eirdosh, D.; Hanisch, S. The Role of Evolutionary Studies in Education for Sustainable Development. In *Darwin's Roadmap to the Curriculum: Evolutionary Studies in Higher Education*; Wilson, D.S., Geher, G., Gallup, A.G., Head, H., Eds.; Oxford University Press: New York, NY, USA, 2019; pp. 229–271.
84. Hanisch, S.; Eirdosh, D. *A Teacher's Guide to Evolution, Behavior, and Sustainability Science*, 2nd ed. 2020. Available online: https://openevo.eva.mpg.de/teachingbase/a-teachers-guide-to-evolution-behavior-and-sustainability-science/ (accessed on 13 March 2023).
85. Erickson, H.L.; Lanning, L.A.; French, R. *Concept-Based Curriculum and Instruction for the Thinking Classroom*; Corwin: Thousand Oaks, CA, USA, 2017; ISBN 978-1-5063-5539-9.
86. Stern, J.; Ferraro, K.; Duncan, K.; Aleo, T. *Learning That Transfers: Designing Curriculum for a Changing World*; Corwin: Thousand Oaks, CA, USA, 2021.
87. Hayes, S.C.; Strosahl, K.D.; Wilson, K.G. *Acceptance and Commitment Therapy. The Process and Practice of Mindful Change*; The Guilford Press: New York, NY, USA, 2012.
88. Hildebrandt, L.K.; McCall, C.; Singer, T. Differential Effects of Attention-, Compassion-, and Socio-Cognitively Based Mental Practices on Self-Reports of Mindfulness and Compassion. *Mindfulness* **2017**, *8*, 1488–1512. [CrossRef]
89. Chudek, M.; Henrich, J. Culture-Gene Coevolution, Norm-Psychology and the Emergence of Human Prosociality. *Trends Cogn. Sci.* **2011**, *15*, 218–226. [CrossRef]
90. Henrich, J.; Muthukrishna, M. The Origins and Psychology of Human Cooperation. *Annu. Rev. Psychol.* **2021**, *72*, 207–240. [CrossRef]
91. Blake, P.R.; McAuliffe, K.; Corbit, J.; Callaghan, T.C.; Barry, O.; Bowie, A.; Kleutsch, L.; Kramer, K.L.; Ross, E.; Vongsachang, H.; et al. The Ontogeny of Fairness in Seven Societies. *Nature* **2015**, *528*, 258–261. [CrossRef]
92. Herrmann, B.; Thöni, C.; Gächter, S. Antisocial Punishment Across Societies. *Science* **2008**, *319*, 1362–1367. [CrossRef] [PubMed]
93. Schäfer, M.; Haun, D.B.M.; Tomasello, M. Fair Is Not Fair Everywhere. *Psychol. Sci.* **2015**, *26*, 1252–1260. [CrossRef] [PubMed]
94. Haskell, R.E. *Transfer of Learning. Cognition, Instruction, and Reasoning*; Academic Press: Cambridge, MA, USA, 2000; ISBN 9780080492353.
95. Willingham, D.T. Critical Thinking: Why Is It So Hard to Teach? *Arts Educ. Policy Rev.* **2008**, *109*, 21–32. [CrossRef]
96. Alfieri, L.; Nokes-Malach, T.J.; Schunn, C.D. Learning Through Case Comparisons: A Meta-Analytic Review. *Educ. Psychol.* **2013**, *48*, 87–113. [CrossRef]
97. Vendetti, M.S.; Matlen, B.J.; Richland, L.E.; Bunge, S.A. Analogical Reasoning in the Classroom: Insights From Cognitive Science. *Mind Brain Educ.* **2015**, *9*, 100–106. [CrossRef]
98. Schwartz, D.L.; Chase, C.C.; Bransford, J.D. Resisting Overzealous Transfer: Coordinating Previously Successful Routines with Needs for New Learning. *Educ. Psychol.* **2012**, *47*, 204–214. [CrossRef]
99. Hanisch, S.; Eirdosh, D. Are Humans a Cooperative Species? Challenges & Opportunities for Teaching the Evolution of Human Prosociality. *Am. Biol. Teach.* **2021**, *83*, 356–361. [CrossRef]
100. Hanisch, S.; Eirdosh, D.; Schäfer, M.; Haun, D. What Is "Fair" Is Not the Same Everywhere. *Front. Young Minds* **2021**, *9*, 580435. [CrossRef]
101. Ostrom, E. *Governing the Commons. The Evolution of Institutions for Collective Action*; Cambridge University Press: Cambridge, MA, USA, 1990.
102. Hinkel, J.; Cox, M.E.; Schlüter, M.; Binder, C.R. A Diagnostic Procedure for Applying the Social-Ecological Systems Framework in Diverse Cases. *Ecol. Soc.* **2018**, *20*, 32. [CrossRef]
103. Obach, B. Barriers to Collective Action: A Classroom Simulation. *Teach. Sociol.* **2003**, *31*, 312–318. [CrossRef]
104. Milinski, M.; Sommerfeld, R.D.; Krambeck, H.-J.; Reed, F.A.; Marotzke, J. The Collective-Risk Social Dilemma and the Prevention of Simulated Dangerous Climate Change. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 2291–2294. [CrossRef] [PubMed]
105. Fehr, E.; Gächter, S. Altruistic Punishment in Humans. *Nature* **2002**, *415*, 137–140. [CrossRef] [PubMed]
106. Hanisch, S. OpenEvo NetLogo Collection. Available online: https://openevo.eva.mpg.de/teachingbase/netlogo/ (accessed on 15 March 2023).
107. Tinbergen, N. On Aims and Methods of Ethology. *Z. Tierpsychol.* **1963**, *20*, 410–433. [CrossRef]

108. Liebal, K.; Haun, D.B.M. Why Cross-Cultural Psychology Is Incomplete without Comparative and Developmental Perspectives. *J. Cross-Cult. Psychol.* **2018**, *49*, 751–763. [CrossRef]
109. Medicus, G. Mapping Transdisciplinarity in Human Sciences. In *Focus on Gender Identity*; Lee, J.W., Ed.; Nova Science Publishers: New York, NY, USA, 2005; pp. 95–114; ISBN 1-59454-212-0.
110. Nesse, R.M. Tinbergen's Four Questions, Organized: A Response to Bateson and Laland. *Trends Ecol. Evol.* **2013**, *28*, 681–682. [CrossRef]
111. Rahwan, I.; Cebrian, M.; Obradovich, N.; Bongard, J.; Bonnefon, J.-F.; Breazeal, C.; Crandall, J.W.; Christakis, N.A.; Couzin, I.D.; Jackson, M.O.; et al. Machine Behaviour. *Nature* **2019**, *568*, 477–486. [CrossRef]
112. Dewsbury, D.A. Essay on Contemporary Issues in Ethology: On the Problems Studied in Ethology, Comparative Psychology, and Animal Behavior. *Ethology* **1992**, *92*, 89–107. [CrossRef]
113. O'Brien, D.T.; Gallup, A.C. Using Tinbergen's Four Questions (Plus One) to Facilitate Evolution Education for Human-Oriented Disciplines. *Evol. Educ. Outreach* **2011**, *4*, 107–113. [CrossRef]
114. Sapolsky, R.M. *Behave—The Biology of Human at Our Best and Worst*; Vintage Books: New York, NY, USA, 2018; ISBN 978-0-09-957506-1.
115. Ariew, A.; Panchanathan, K. Adding Agency to Tinbergen's Four Questions. In *Evolutionary Thinking Across Disciplines—Problems and Perspectives in Generalized Darwinism*; du Crest, A., Valković, M., Ariew, A., Desmond, H., Huneman, P., Reydon, T., Eds.; Springer: Berlin/Heidelberg, Germany, 2023.
116. Böhm, G.; Pfister, H.R. How People Explain Their Own and Others' Behavior: A Theory of Lay Causal Explanations. *Front. Psychol.* **2015**, *6*, 139. [CrossRef]
117. Basile, A.J.; Renner, M.W.; Hidaka, B.H.; Sweazea, K.L. An Evolutionary Mismatch Narrative to Improve Lifestyle Medicine: A Patient Education Hypothesis. *Evol. Med. Public Health* **2021**, *9*, 157–163. [CrossRef]
118. Sherry, D.S. Does Knowledge of Evolutionary Biology Change High School Students' Attitudes about Healthy Eating? *Evol. Educ. Outreach* **2019**, *12*, 19. [CrossRef]
119. Nettle, D.; Frankenhuis, W.; Panchanathan, K. Biology, Society, or Choice: How Do Non-Experts Interpret Scientific Explanations of Behaviour? *PsyArXiv Preprint* **2022**. [CrossRef]
120. NGSS. *Lead States Next Generation Science Standards: For States, by States 2013*; The National Academies Press: Washington, DC, USA, 2013.
121. Jacobson, M.J. Problem Solving, Cognition, and Complex Systems: Differences between Experts and Novices. *Complexity* **2001**, *6*, 41–49. [CrossRef]
122. Rogers, E.M.; Medina, U.E.; Rivera, M.A.; Wiley, C.J. Complex Adaptive Systems and the Diffusion Of Innovations. *Innov. J. Public Sect. Innov. J.* **2005**, 10.
123. Henrich, J. Cultural Transmission and the Diffusion of Innovations: Adoption Dynamics Indicate That Biased Cultural Transmission Is the Predominate Force in Behavioral Change. *Am. Anthropol.* **2001**, *103*, 992–1013. [CrossRef]
124. Mesoudi, A. Cultural Evolution: Integrating Psychology, Evolution and Culture. *Curr. Opin. Psychol.* **2016**, *7*, 17–22. [CrossRef]
125. Cox, M.; Elen, J.; Steegen, A. The Use of Causal Diagrams to Foster Systems Thinking in Geography Education: Results of an Intervention Study. *J. Geogr.* **2019**, *118*, 238–251. [CrossRef]
126. Hoffmann, T.; Menon, S.; Morel, W.; Nkosi, T.; Pape, N. *Zehn Stufen zum Systemischen Denken*; Center for Environment Education: Thaltej Tekra, Indien, 2022.
127. Hanisch, S.; Eirdosh, D. Causal Mapping as a Teaching Tool for Reflecting on Causation in Human Evolution. *Sci. Educ.* **2021**, *30*, 993–1022. [CrossRef]
128. Bowles, S.; Gintis, H. *A Cooperative Species. Human Reciprocity and Its Evolution*; Princeton University Press: Princeton, NJ, USA, 2011; ISBN 978-0-691-15125-0.
129. Poteete, A.R.; Janssen, M.A.; Ostrom, E. *Working Together: Collective Action, the Commons, and Multiple Methods in Practice*; Princeton University Press: Princeton, NJ, USA, 2010; ISBN 978-0-691-14603-4.
130. Kline, M.A.; Waring, T.M.; Salerno, J. Designing Cultural Multilevel Selection Research for Sustainability Science. *Sustain. Sci.* **2018**, *13*, 9–19. [CrossRef]
131. Polk, K.L.; Schoendorff, B. *The ACT Matrix: A New Approach to Building Psychological Flexibility across Settings and Populations*; Context Press/New Harbinger Publications: Oakland, CA, USA, 2014; ISBN 978-1-60882-923-1.
132. Tenaglia, P. The Matrix for Education Starter Manual—Developing Psychological Flexibility For Learners, Educators and Parents. pp. 1–38. Available online: http://www.philtenaglia.com/matrix-education/ (accessed on 13 March 2023).
133. Hayes, S.C.; Luoma, J.B.; Bond, F.W.; Masuda, A.; Lillis, J. Acceptance and Commitment Therapy: Model, Processes and Outcomes. *Behav. Res. Ther.* **2006**, *44*, 1–25. [CrossRef]
134. 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. [CrossRef] [PubMed]
135. Chase, J.A.; Houmanfar, R.; Hayes, S.C.; Ward, T.A.; Vilardaga, J.P.; Follette, V. Values Are Not Just Goals: Online ACT-Based Values Training Adds to Goal Setting in Improving Undergraduate College Student Performance. *J. Context. Behav. Sci.* **2013**, *2*, 79–84. [CrossRef]
136. Cohen, G.L.; Garcia, J.; Apfel, N.; Master, A. Reducing the Racial Achievement Gap: A Social-Psychological Intervention. *Science* **2006**, *313*, 1307–1310. [CrossRef] [PubMed]

137. Hulleman, C.S.; Harackiewicz, J.M. Promoting Interest and Performance in High School Science Classes. *Science* **2009**, *326*, 1410–1412. [CrossRef] [PubMed]
138. Miyake, A.; Kost-Smith, L.; Finkelstein, N.; Pollock; Cohen, G.; Ito, T. Reducing the Gender Achievement Gap in College Science: A Classroom Study of Values Affirmation. *Science* **2010**, *330*, 1234–1237. [CrossRef] [PubMed]
139. Hanel, P.H.P.; Roy, D.; Taylor, S.; Franjieh, M.; Heffer, C.; Tanesini, A.; Maio, G.R. Using Self-Affirmation to Increase Intellectual Humility in Debate. *R. Soc. Open Sci.* **2023**, *10*, 220958. [CrossRef]
140. Porter, T.; Baldwin, C.R.; Warren, M.T.; Murray, E.D.; Cotton Bronk, K.; Forgeard, M.J.C.; Snow, N.E.; Jayawickreme, E. Clarifying the Content of Intellectual Humility: A Systematic Review and Integrative Framework. *J. Pers. Assess.* **2022**, *104*, 573–585. [CrossRef]
141. Hayes, L.L.; Ciarrochi, J. *The Thriving Adolescent—Using Acceptance and Commitment Therapy and Positive Psychology to Help Teens Manage Emotions, Achieve Goals, and Build Connections*; Context Press: Oakland, CA, USA, 2015.
142. Glynn, S.M. Making Science Concepts Meaningful to Students: Teaching with Analogies. In *Four Decades of Research in Science Education: From Curriculum Development to Quality Improvement*; Mikelskis-Seifert, S., Ringelband, U., Brückmann, M., Eds.; Waxmann: Münster, Germany, 2008; pp. 113–125.
143. Hanisch, S.; Eirdosh, D.; Morgan, T. Evolving Cooperation and Sustainability for Common Pool Resources. In *Learning Evolution through Socioscientific Issues*; Sá-Pinto, A.X., Beniermann, T., Børsen, M., Georgiou, A., Jeffries, P., Pessoa, B., Sousa, D.L., Zeidler, Eds.; UA Editora: Aveiro, Portugal, 2023; pp. 127–147.
144. Wilson, D.S.; Ostrom, E.; Cox, M.E. Generalizing the Core Design Principles for the Efficacy of Groups. *J. Econ. Behav. Organ.* **2013**, *90*, S21–S32. [CrossRef]
145. Hofstadter, D.R.; Sander, E. *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking*, 1st ed.; Basic Books: New York, NY, USA, 2013; ISBN 978-0-465-01847-5.
146. Brand, C.O.; Mesoudi, A.; Smaldino, P.E. Analogy as a Catalyst for Cumulative Cultural Evolution. *Trends Cogn. Sci.* **2021**, *25*, 450–461. [CrossRef]
147. OECD. *Curriculum (Re)Design: A Series of Thematic Reports from the OECD Education 2030 Project. Overview Brochure*; OECD: Paris, France, 2020.
148. Cope, B.; Kalantzis, M. *A Pedagogy of Multiliteracies. Learning by Design*; Palgrave Macmillan: New York, NY, USA, 2015.
149. Eirdosh, D.; Hanisch, S. A Community Science Model for Interdisciplinary Evolution Education and School Improvement. In *Evolutionary Thinking across Disciplines—Problems and Perspectives in Generalized Darwinism*; du Crest, A., Valković, M., Ariew, A., Desmond, H., Huneman, P., Reydon, T., Eds.; Springer: Berlin/Heidelberg, Germany, 2023.
150. Hanisch, S.; Eirdosh, D. Cooperation as a Causal Factor in Human Evolution: A Scientific Clarification and Analysis of German High School Biology Textbooks Textbooks. *J. Biol. Educ.* **2022**. [CrossRef]
151. McKenney, S.; Reeves, T.C. *Conducting Educational Design Research*; Routledge: London, UK, 2019.
152. Eirdosh, D. Teaching Evolution as an Interdisciplinary Science: Concepts, Theory, and Network Infrastructure for Educational Design Research. Ph.D. Thesis, Friedrich-Schiller-University Jena, Jena, Germany, 2022.