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A Teacher's Guide to Evolution, Behavior, and Sustainability Science

Third Edition

Susan Hanisch & Dustin Eirdosh











This guide has been created as a collaboration between the department of Comparative Cultural Psychology at the Max Planck Institute for evolutionary anthropology, the Biology Education research group of the Friedrich Schiller University of Jena, and the University of Leipzig, with the support of the John Templeton Foundation (Grant number 62318).

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Publication in pdf format available for free at: https://openevo.eva.mpg.de/teachingbase/teachers-guide



print ISBN: 978-3-9821193-9-7

Citation: Hanisch, S., Eirdosh, D. (2024). A Teacher's Guide to Evolution, Behavior, and Sustainability Science. 3rd Edition. Leipzig/Jena, Germany.



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Dear Reader,

This guide is intended for educators, students, and others interested in advancing Education for Sustainable Development (ESD) through the lens of evolutionary and behavioral sciences.

Our approach to ESD is informed by the human sciences that offer valuable perspectives and tools for understanding the challenges and solutions to human well-being and sustainability, as well as for developing a variety of competencies.

The purpose of this guide is to offer an introduction to the **big ideas** and **core understandings** that we think are relevant for understanding the role of human behavior in sustainable development, from across evolutionary, behavioral, and sustainability sciences. Additionally, it provides a set of **practical tools** that can help teachers to **adapt and design lessons** for various classroom contexts. Specifically, this guide outlines our **educational design concept for teaching human behavior as an interdisciplinary theme** - comprising three *design principles*, nine *content anchors*, a number of *thinking tools*, and *pedagogical approaches* that can be integrated to create a wide diversity of lessons and units working towards the big understandings of human evolution, behavior, and sustainable development.

In this **third edition of the teacher's guide**, we have added and expanded upon some new content and design elements and we present our **OpenEvo online educational innovation infrastructure**, where you can find more information such as teaching materials and online resources, publications, and research tools.

Throughout the document you will find QR-Codes such as the one on the right, with hyperlinks in the digital version of this document. These lead you to further online resources on our website.



Link to the OpenEvo website

We invite you to **get involved!** Think about how the ideas and content in this guide relate to your everyday experience and to your teaching and learning goals. **Try things out** and **connect with us** to share your experiences, give us feedback, join our efforts in educational innovation, or ask us a question.

Best Regards, Susan Hansich & Dustin Eirdosh



Dear Reader,

At the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, we study the origins and diversity of humans and their close relatives from an interdisciplinary perspective. At the Department of Comparative Cultural Psychology of the institute, we combine approaches from developmental, cross-cultural, and comparative psychology to study human cultural diversity and the cognitive mechanisms that enable and constrain it.

At a time of social conflict and political polarization, social inequality, discrimination, spread of misinformation, and rising mental health problems, studying and understanding humans is more than a scientific curiosity - we think it is vital for solving many of the world's challenges to human well-being and a peaceful sustainable coexistence. But this requires that all humans are empowered with a deeper understanding of themselves and their fellow humans.

This is why I am excited about this teacher guide. It embodies our commitment to bring insights from the interdisciplinary human sciences into classrooms worldwide. I hope it serves as a valuable and inspiring resource for educators and learners.

Prof. Dr. Daniel Haun

Director of the Department of Comparative Cultural Psychology Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Dear Reader,

Evolution is a central topic in the biology curriculum, but it may not be obvious to teachers or students how it is relevant to their lives or to current issues of sustainable development. Instead, the role of the subject of biology in sustainability education is often seen in topics like ecology, biodiversity, and natural resources.

This guide offers a unique and innovative perspective - it explores the central role of human behavior and of evolutionary dynamics in sustainable development. It argues that understanding the deeper evolutionary and historic causes of our everyday behaviors and cultures can support students in developing many important competencies, including self-reflection, critical thinking, and social skills.

This guide gives biology educators, as well as educators of many other subjects, new ideas to connect the themes of human well-being and sustainable development to topics of the curriculum. I hope it will have a positive impact on how human evolution is taught in biology and interdisciplinary classrooms in the future.

Prof. Dr. Uwe Hoßfeld Leader of the Biology Education Research Group Friedrich-Schiller University Jena, Germany

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Today's global society faces major challenges in ensuring resource availability, social equality, peaceful coexistence, access to good education, health, and human well-being for all. The United Nations has identified 17 global goals for sustainable development, aiming to reach specific markers of success in each area by the year 2030.



All of these goals require **collaboration**, **innovation**, **and flexibility** across many levels of society, including up to the unprecedented scale of global cooperation.

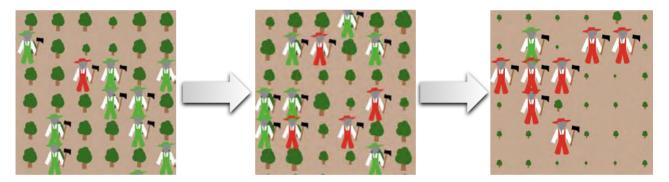
What can we learn from other living beings, from our shared evolutionary history as a species, from communities and cultures around the world, and from our everyday experiences and behaviors about which factors might foster or hinder our abilities to cooperate, learn, innovate, and reorient our behaviors and cultures towards these valued outcomes?

Research in biology, economics, anthropology, psychology, and behavioral sciences offers us clues about the origins, diversity and flexibility of our species, and about the conditions and principles that play a role in enabling the sustainable development and well-being of diverse communities.

Box 1. The basic dilemma of using shared resources

Sustainable development involves the maintenance of shared and limited natural and social resources. In such situations there is always the threat of competition between individuals endangering the maintenance of a shared resource, and thus the sustainability of the whole community.

Individuals often have an interest in using as much of a resource as possible (or contributing as little as possible to the conservation of that resource). After all, their behavior may have only little immediate negative consequences for the community. However, when most people in the community act like this, the entire resource becomes endangered, with negative consequences for everyone. This **social dilemma** between short-term personal advantage and the long-term common good in the use of shared resources is called the **tragedy of the commons**¹.



The Common-Pool Resource Dilemma: What prevents an individual from taking as much as possible from a shared resource? Greed, anger, and envy may then entice others to increase their resource use as well. After all, nobody wants to be exploited and at a disadvantage. However, if everyone does so, resource availability is jeopardized for all.

The tragedy of the commons is an important concept in evolutionary, behavioral, and sustainability sciences. It also presented a puzzle for a long time. After all, we can observe that many species of animals, as well as many groups of people, have apparently managed to cooperate and thus prevent the tragedy of the commons.

What conditions and behaviors enable them to do this?

Box 2. Are we "all in the same boat"?

The use of community resources is a dilemma only when the interests of individuals are not clearly in line with the interests of the community. Some scientists like to use the **boat-analogy** to describe situations in relation to how individuals' interests are related to the interests of others, whether self-interest and collective interest are in line or opposed.

Does everyone sit in his or her own boat, only concerned with their own direction? Is it irrelevant to one's survival how those in the other boats behave? In such a scenario, there is no social interaction - neither competition nor cooperation.



Is everyone sitting in the same boat? Is the success or failure of one the success or failure of the others? In this scenario, we can expect that, over time, cooperation emerges or wins - everyone has the same aim, because everyone is interested in moving their boat together towards a safe destination. Moreover, those groups that cooperate better than other groups will have an advantage in the long-term.





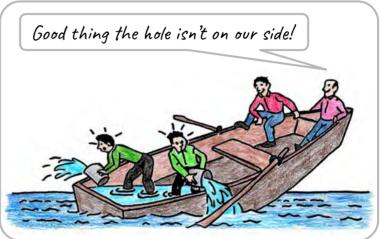
Does everyone sit in his or her own boat, and are all boats in a race? Does the victory of one equal the defeat of the others? If this is the case, then we can expect that there is competition - all are interested in defeating the other boats. Those who are faster, stronger, more efficient, or smarter than the others will have the long-term advantage.



Box 2. (continued) Are we "all in the same boat"?

In reality, situations rarely fall cleanly into one of these boat scenarios, and situations often change. Often, self-interest and the common good are neither perfectly aligned, nor perfectly opposed. Selfish behavior is often worthwhile in the short term, but not in the long term. These unclear situations can lead to a hard to solve dilemma between short-term individual advantage and long-term common good.

When everyone is in the same boat, it is beneficial for everyone to work together. Competition or cheating within the group can, sooner or later, lead to the downfall for everyone.



"Suppose that two people, Art and Bud, are at sea in a rowboat, trying to stay ahead of a violent storm. Neither will survive unless both row as hard as possible. Here self-interest and collective interest (in this case, a collective of two) are in perfect harmony. For both Art and Bud, doing what's best for "Me" and what's best for "Us" is the same. In other cases, cooperation is impossible. Suppose, for example, that Art and Bud's boat is now sinking and that they've only one life vest, which can't be shared. Here there is no Us, just two different Me's.

When cooperation is easy or impossible, as in the two scenarios above, there's no social problem to be solved. Cooperation becomes a challenging but solvable problem when, as in [the tragedy of the commons], individual interest and collective interest are neither perfectly aligned nor perfectly opposed. (...) The problem of cooperation, then, is the problem of getting collective interest to triumph over individual interest, when possible. The problem of cooperation is the central problem of social existence."

Joshua Greene (2013), p. 20

Part of our educational approach is the engagement with and reflection of concepts, their relations, and their critical application to help us understand a variety of phenomena (\rightarrow p. 53).

Concepts are abstract ideas that we express with words. The concepts of social dilemma, tragedy of the commons, and the boat analogy were introduced in the previous pages because they help us make sense of many human behaviors and their causes as well as many problems of sustainable development. You will find references to these ideas throughout this guide.

Evolution, behavior, and **sustainability** are further high-level concepts that run through this guide. Let's dive right in and look at some ways to teach for conceptual understanding by exploring these three concepts.

It is very likely that you as the reader have heard these words before and have the sense that you know what concepts they are meant to describe. But how exactly would you define these concepts? What phenomena do you think they do and don't apply to? And how do these concepts relate to each other?

You may find that, despite your familiarity with these words, it is not so easy to define the concepts they refer to. Your understanding might also be quite different from the understanding of others. It turns out, even scientists do not fully agree on what these words and concepts mean. Just like people in general, different scientists may use different definitions of these concepts, because they are interested in different things, and they use these concepts to achieve different goals. Misunderstandings often emerge if people don't clarify the specific ways they are using words in a particular context.

Our understanding of these concepts also influence the degree to which we think they relate to each other, as well as the degree to which we think the concepts might be useful for understanding particular phenomena.

We believe that engaging in deeper understandings of the concepts of evolution, behavior, and sustainability is helpful for understanding and acting in our world. After all, we humans are influenced by past and current evolutionary processes, we exhibit many different behaviors that impact ourselves and the world, and we care about sustaining certain things.

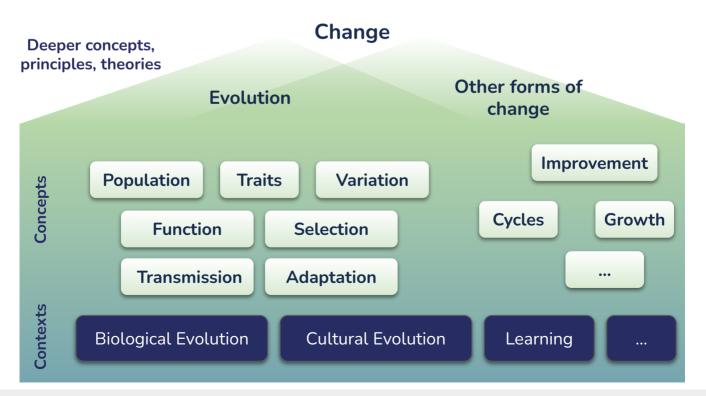
What is Evolution?



How would you define evolution? What ideas do you associate with it? What are some examples of evolution?

We can understand evolution in different ways. Scientists also define and study evolution in different ways. At the most general level, evolution describes change. But is it the same as change? One can say that evolution describes particular kinds of changes: changes in the frequencies and distribution of traits in populations or systems that result from variation in traits and processes that make some traits more common than others. So, the concept of evolution uses further concepts to explain change, like population, variation, function, selection, inheritance, adaptation, and fitness. What is the relationship between evolution and the concepts "progress" or "improvement"? Many scientists emphasize that evolution is not the same as progress or improvement - indeed, evolution can lead to outcomes that we humans would not call progress.

A helpful way to visualize the relationship between these concepts is a **Structure** of Knowledge diagram (\rightarrow p. 159 ff.). It's a kind of concept map that links ideas on different levels of generality all the way down to specific phenomena and facts. Here is an example of a structure of knowledge diagram that links some of the concepts mentioned in the previous paragraph.



What domains or phenomena can be said to *evolve* through processes of trait variation, selection, and transmission?

In an educational context, most people probably come across evolution in the biology classroom, and you might associate it with **biological phenomena** like genes, some species that were presented in your textbook like Giraffes, finches, or peppered moths, dinosaurs, maybe some fossils and tools of our ancestors.

"Nothing in biology makes sense except in the light of evolution."

Dobzhansky (1973), p. 125

Many scientists also understand and use the theory of evolution beyond the domains of biological species and genes. For example, cultural evolution scientists use elements of the theory of evolution to understand and investigate **cultural change**.

"Nothing about culture makes sense except in the light of evolution"

Richerson & Boyd (2005), p. 237

"The core idea of cultural evolution is that cultural change constitutes an evolutionary process that shares fundamental similarities with – but also differs in key ways from – genetic evolution."

Cultural Evolution Society (2023)

Some psychologists even borrow elements of the theory of evolution to understand how **learning** happens over the lifetime of an organism.

"Reusing behaviours that have been successful in the past (reinforcement learning) is intuitively similar to the way selection increases the proportion of fit phenotypes in a population. In fact, evolutionary processes and simple learning processes are formally equivalent."

Watson & Szathmary (2016), p.2

"Operant reinforcement resembles the natural selection of evolutionary theory. Just as genetic characteristics which arise as mutations are selected or discarded by their consequences, so novel forms of behavior are selected or discarded through reinforcement "

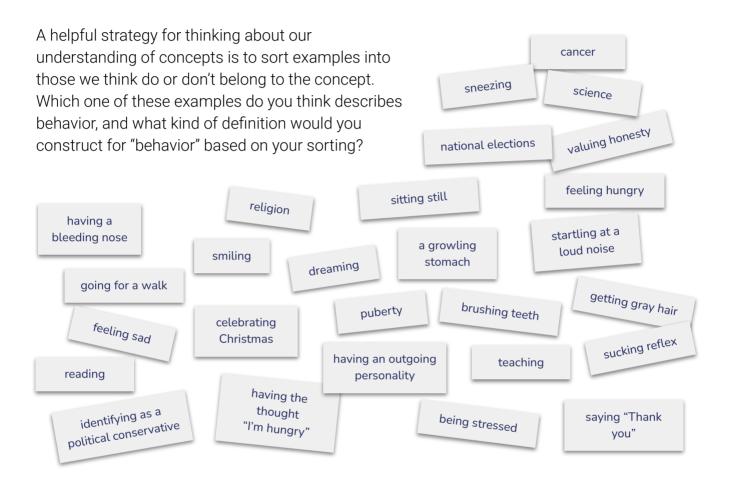
B. F. Skinner (1953), p. 430

Analogies and analogy maps (\rightarrow p. 155 ff.) are important tools in science and education for fostering conceptual learning, deeper theory-building and learning transfer. Here is an example of an analogy map that compares change in the domains of genetic evolution, cultural evolution, and learning through the lens of evolutionary concepts. Importantly, while there are no "perfect analogies", many analogies can be helpful. What do you think might be the (educational) value of thinking of cultural change and learning as evolutionary change?

	Genetic evolution	Cultural evolution	Learning
What changes are focused on?	The diversity and frequency of genes/ alleles in a population of organisms	The diversity and frequency of cultural traits in a population of organisms: e.g. behaviors, beliefs, ideas, knowledge, traditions and norms, social organisations and institutions, technologies, infrastructures	The repertoire and frequency of behaviors in an organism (e.g. thoughts, feelings, knowledge, beliefs, values, habits, body movements)
What are the causes of new variation in traits?	Random mutations and recombination of genes	Accidents and mistakes, creativity, openness to novelty, recombination of ideas; behavioral and cultural change as response to novel environments	Accidents and mistakes, creativity, trial-and-error, social learning, behavior change as response to novel environments
How does the " selection " of traits occur?	The trait (gene/allele) increases the chances of reproduction under the given environmental conditions	Reproductive success; imitation biases and/or preferences that motivate individuals (consciously or unconsciously) to imitate or teach others - such as imitating cultural traits that are attractive or easy to learn, imitating prestigious and successful people, or imitating the majority	The behavior leads to the fulfillment of a goal or is in line with values (reward system); the behavior is in line with previous learning (can be easily assimilated)
How is the trait inherited , transmitted , or retained within the population?	Biological reproduction and inheritance of genetic material to offspring	Imitation/social learning, teaching, communication (passing on to both offspring and others); accumulation of artefacts and structures that persist in the environment over time	Reinforcement; encoding in the nervous system (myelination) and in long-term memory

What is Behavior?

An even more familiar and everyday term is behavior. What is behavior, and what phenomena count as behavior? Here as well, constructing a definition is not so simple, and scientists disagree as well¹.



Questions that might come up during this sorting activity:

- Are thoughts and feelings, and other things that happen "inside" of us, without any bodily movement, behaviors?
- Is "doing nothing", or not moving, also behavior?
- Is stuff that happens to and within our body, such as injuries, disease, developmental changes, heart-beat and other physiological processes, behavior?
- Are things that groups of people do like an election, a protest, a religion, science also behaviors?

¹ Levitis et al. (2009)

One area of strong agreement among scientists is that **behavior is something organisms do in response to internal and external stimuli**. Developmental changes or injuries and illnesses are usually not considered behaviors. Furthermore, **behaviors might be expressed by individuals, but also by groups**. For example, a flock of birds flying in V-formation is a behavior of the whole flock. A protest movement or a social norm are behaviors of a group of people¹.

One area of disagreement is whether internal processes like thinking, knowing, and feeling count as behavior. Behavioral biologists often don't regard these things as behavior, while many psychologists do. Psychologists often distinguish between "overt" (i.e. visible) outer behaviors, and "covert" (i.e. invisible) inner behaviors..

We think that regarding thinking, feeling, valuing, knowing, believing, imagining etc. as behavior has some educational value: we can **use the concepts and tools of behavioral science** to be more **aware of them**, **understand** them better, have a **more helpful relationship** with them, or **change them more flexibly**.



Examples of human behaviors whose causes, consequences, diversity, and flexibility we can explore with the tools and concepts of behavioral science

What is Sustainability?

How would you define and what do you associate with the term "sustainability"? Which phenomena does it apply to? You might think about ecological aspects like climate change, plastic pollution, recycling, biodiversity, or saving of resources; you might also include the idea of the future. You might also think of social and economic aspects, and you might think that any one of these is more important than the others.

A more general understanding of sustainability, which we will adopt in this guide, is about human (and other orgainsms') needs and values, and sustaining well-being into the future.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

G. H. Brundtland (1987)

"The term "sustainability" has two connotations. First, sustainability is a goal state that includes the maintenance of the environment and human well-being. Second, sustainability also means the durability of a given state over time, i.e., its resilience to perturbation.

However, not all resilient states are desirable, nor are all desirable states resilient. (...)

Human values must determine the desired state (...), whereas science must determine the process to achieve and maintain that state (...)."

Waring et al. (2015)

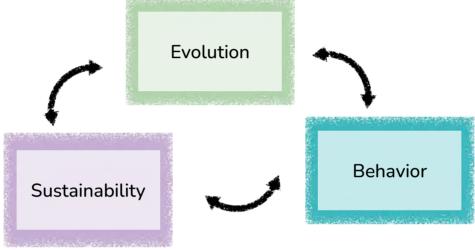
As with all definitions, these definitions contain further concepts, like resilience, future, needs, values, and well-being. These are further concepts we can try to explore and define.

The Global Sustainable Development Goals (SDGs) (\rightarrow p. 6) are one way to capture what humans collectively might need, value, and therefore care about sustaining and regenerating. However, communities and individuals might value different things and might disagree about which goals and behaviors are desirable and serve human needs. Things that are valued and considered important might also change over time. For example, the spread of misinformation (\rightarrow p. 120) or the impacts of technologies on society (\rightarrow p. 103) might be important issues of our time that are not well captured in the SDGs.

The point is that we can look at almost any topic or phenomenon through the lens of sustainability and associated concepts: How does it relate to our goals and values? How might it affect the future? How might it contribute to the well-being of the creatures we care about? How does it affect the resilience of a system? What can we learn from it about sustainable development?



After reflecting about and deepening our understandings of evolution, behavior, and sustainability, we can begin to ask questions about the relationships between them. For example: How does evolution impact behavior? How does behavior impact evolution? How do human behaviors impact sustainability? What behaviors do humans show when they have their needs met, or when they don't have their needs met? What is the relation between sustainability and evolution?



These are the big questions that this guide and our educational design concept are about. Our educational goal is to help you and your students construct, communicate, reflect, modify, and expand on their own answers to these questions as they learn more about human evolution, human behavior, human needs and values, and sustainable development.

Let's take the question "How does human behavior affect sustainability?" as an example. This guide is about exploring many possible answers to this question. In general, human behaviors can have both positive and negative impacts on sustainable development. For example, the human tendency to imitate others around them and to intuitively follow social norms can lead to the spread of both desirable and undesirable behaviors and norms.

Human behavioral concepts can therefore serve as overarching concepts that connect our everyday experience of being human to a variety of sustainability issues.

Let's look at another example - the question "How does evolution impact behavior?" Research and our own experience in classrooms indicate that humans tend to largely focus on more proximate causes when attempting to explain human behavior¹ or to regard different causes as incompatible².

Tinbergen's questions (\rightarrow p. 140 ff.) are a helpful framework that reminds us that causes of behavior can also include the cultural and evolutionary history, and that we also have to inquire about the function that a behavior might have for someone in their particular context.

We think that this understanding can contribute to the development of more helpful mental models about what it means to be human and of a variety of helpful attitudes and competencies (\rightarrow p. 25 ff.).

In fact, challenges of sustainable development are not fundamentally new to us humans. Throughout our **evolutionary history**, our species has been confronted time and again with **challenges of collaboration**, **collective learning**, and the **sharing** of limited resources. This is because our ancestors lived in groups where everyone was **"in the same boat"** - everyone was dependent on preserving the group and its resources, both natural and social. These challenges have significantly **shaped the cognitive and social capacities**, **psychological needs, motivations, behaviors, and cultures of our species**. These human traits still influence our everyday experience and our world today, both in positive and in negative ways.

In this context, an understanding of both recent and distant causes and consequences of human behavior, as well as of the causal relationships that have shaped our past, shape our present, and will shape our future, can help us to better understand today's challenges to human well-being and sustainable development, and to design and evaluate possible solutions.

Box 3. Human Behavior, Nature of Science, & Mental Models

Humans are complex systems and human behavior has many causes. It is much more difficult to predict what a human will do than to predict what will happen when we drop a stone on a slope. One sign of the complexity of human behavior is the replication and generalization "crisis" in psychology: often psychologists don't get the same results when they repeat an experiment that someone else has done. It shows that it is difficult to draw any general and uncritical conclusions about human nature from a few experiments and observations.

Nonetheless, or precisely because of this complexity, biologists, psychologists, and other behavioral scientists aim to identify *generalizations* and *principles* that allow them to describe some general patterns and even to predict and influence what humans (or other animals) might do and how they might develop under certain conditions. Psychologists have become aware that in order to do this, we need to study many humans across cultures, across ages, under many different conditions, and over longer time spans. Furthermore, to understand what makes us all human or where in the evolutionary history our behaviors might have emerged, we also have to study other species.

Beyond science, humans also develop many more or less intuitive **mental models** about human nature through their own experiences and through learning from others. Humans also make sense of their world through narratives - we want and need some coherent story in order to act in the world. These mental models and stories in turn affect our behaviors and attitudes towards ourselves and others, including our ability to develop competencies.

How then can we explore the theme of human behavior in the classroom across different subjects, and how can we help students develop mental models that are both in line with science *and* helpful? We argue that students should mainly be given the *tools* to be aware of and think about human behavior - their own and others' - such that they can flexibly and metacognitively shape their mental models towards those that might be most helpful for their own lives and for contributing to society. Students should also be enabled to develop **critical thinking** skills and an attitude of **intellectual humility** (\rightarrow p. 121) in order to continuously and flexibly adapt their mental models.

We strive for both **pluralism and coherence** - meaning that the educational goal is not necessarily the understanding of one particular theory, scientific perspective, or narrative about human behavior, but the ability to flexibly move in a conceptual space and explore connections, generalities, coherence, similarities, complementarities as well as differences, complexities, and inconsistencies between ideas. The elements and pedagogical approaches integrated in our design concept, particularly the thinking tools and the **focus on conceptual learning**, allow this reflection as well as an open-endedness towards answers and narratives about human nature.

And so, we find that the **research questions, concepts, methods, findings** and interdisciplinary connections of the **evolutionary, behavioral, and sustainability sciences** offer unique opportunities to explore the causes and consequences of human behavior in the classroom. Thus, they can contribute to a fascinating and interdisciplinary education that connects to our shared everyday experience, is relevant to pressing societal challenges, and supports students in the **development and reflection of their own behaviors and competencies**.

The educational design concept presented in this document (\rightarrow p. 38 ff.) offers practical guidance for the development of teaching materials, lessons, and units that aim to support students and teachers in reflecting on the everyday experience of human behavior in the light of evolution and sustainability.

"We would argue that there is a major difference between behavioral science (...) and every other area of scientific progress. (...) Most people who make daily use of the technologies that have so changed the world in the past century, need not understand the science that led to and underpins the efficacy of their computers, cell phones, televisions, automobiles, air conditioners, and so on. (...)

The situation is a little different when it comes to the behavioral sciences (...). [T]ranslating the advances in scientific understanding of human development into comparable improvements in human well-being requires that we get most people in society to understand – at least in rough outline – what humans need to thrive."

Biglan et al. (2016), p. 537, 538

Exploring human behavior in the classroom offers further learning opportunities. Students of all ages, and humans in general, are very interested in human behavior - we experience it on a daily basis and we are constantly concerned with and imagine its causes and consequences. In addition, human behavior is implicitly or explicitly integrated in the curricula of many school subjects, especially in biology, social studies, history, geography, literature, art, or ethics. Educational goals often include the development of various competencies, which are themselves human behaviors we can explore.



With our educational innovation work, we aim to cultivate a variety of competencies in learners (\rightarrow p. 25 ff.) and contribute to equitable well-being and prosociality. Our **Theory of School Improvement** serves to organize and focus the elements of our work on educational innovation towards these aims under the given context of education systems.

Historical and modern socio-cultural factors - such as the disciplinary structure of the curriculum, issues of curriculum overload, and standardized testing¹ coalesce to make it exceedingly difficult for teachers to engage with human behavior as an interdisciplinary theme for the development of core student competencies. Human behavior seems to be "everywhere and nowhere" in the curriculum. Students might learn disconnected, maybe even fundamentally contradicting things about humans in the biology, economics, history, language, geography, or ethics classrooms.

When it comes to understanding humans, we want to help teachers and students see the forest for the trees - to be able to critically connect and transfer disciplinary perspectives into a more coherent and helpful core, while navigating plurality, disagreement, and uncertainty.



¹ OECD (2020)

Theory of School Improvement

Therefore, we target the strategic development of curricula as well as interdisciplinary teacher education and professional development opportunities in order to help teachers develop their Pedagogical Content Knowledge (PCK) to teach about human behavior across traditional subject areas and grades.

With the development of these professional competencies, teachers can enable students and others to reflect on and develop their **conceptual understanding of human behavior**, as well as to **apply their understandings** towards **improving their own lives and their school culture and communities**.

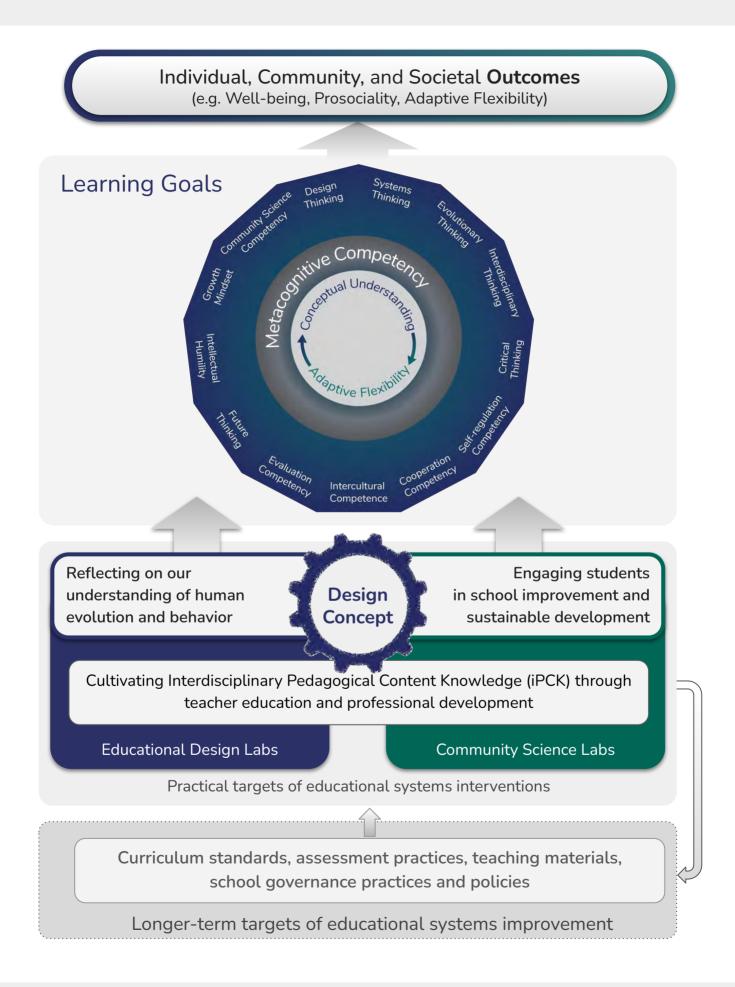
The interplay between these academic and applied learning domains can serve to further reinforce student and teacher conceptual understanding of human behavior as well as their skills for **adaptive flexibility**, both of which are hypothesized to be foundational in the **metacognitive development of competencies**¹.

To target these various areas of educational systems interventions, OpenEvo is building tools, methods, and infrastructure for the collaborative and networked development and evaluation of educational innovations.

Our *Educational Design Lab* focuses on the development of innovative materials and curricula as well as educational design guidance to teach about human behavior across subjects and grades.

Our *Community Science Lab* focuses on the development of tools, materials, and infrastructure to enable students to investigate and improve their own communities through the concepts and methods of behavioral science.

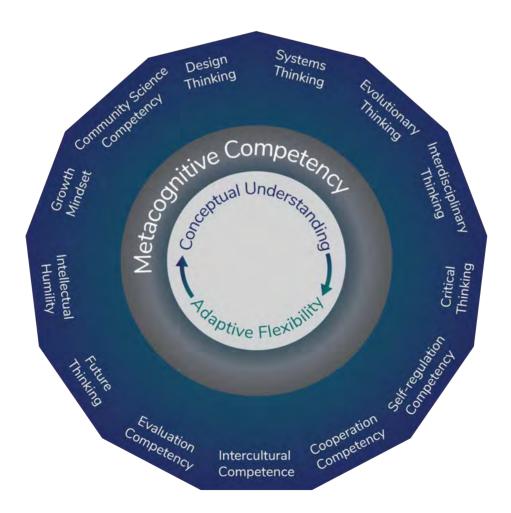
Theory of School Improvement





With our educational design work, we aim to promote a range of interdependent **competencies and mindsets or attitudes** within students and teachers. These draw on and overlap with competency frameworks that have been developed within Education for Sustainable Development and similar movements of 21st century education¹.

Our approach to the development of these competencies is centered around **metacognitive competency**². That is, we hypothesize that the **development**, **reflection**, and self-regulation of these competencies - which are in themselves human behaviors - can be supported by, on the one hand, deepening and broadening learners' conceptual understanding of human behavior, and on the other hand, by practicing and experiencing adaptive flexibility, including through active involvement of learners in self-directed behavior change and community improvement efforts.



Metacognitive Competency

Metacognitive competency is the ability to be aware of, evaluate, flexibly reorganize, and regulate one's own thinking and behavior, including one's learning and one's understanding of concepts as well as one's behaviors related to important competencies and values. We regard metacognitive competency as a foundation for driving the development of all other competencies.

Systems Thinking

Systems thinking includes the abilities to recognize and understand causal relationships in complex systems on different levels, from the self to the global level, and within different domains; to analyze complex systems and recognize dynamics such as multiple causality, non-linearity, feedback loops, delays, and emergence; and to deal with uncertainty.

Thinking tools such as as causal maps (\rightarrow p. 143 ff.) and payoff matrices (\rightarrow p. 149 ff.) as well as computer models of complex systems (\rightarrow p. 98 ff.) can help students develop systems thinking competency.

Evolutionary Thinking

Evolutionary thinking, similar to systems thinking, involves the abilities to understand and analyze change in populations and complex systems over various scales of time through the dynamics of decentralized processes of variation, selection, and information transmission or retention as well as the goal-directed behaviors of agents.

Thinking tools such as **causal maps** (\rightarrow p. 143 ff.), **Tinbergen's questions** (\rightarrow p. 140 ff.) and **analogy maps** (\rightarrow p. 155 ff.) for the transfer of evolutionary processes across domains, as well as various Content Anchors (\rightarrow p. 41 ff.) can help students develop evolutionary thinking competency and apply evolutionary concepts to the analysis of change in ecosystems, self, culture, and society.

Interdisciplinary Thinking

Interdisciplinary thinking is the ability to apply, transfer, and combine knowledge, concepts, principles, skills, and methods of different disciplines to understand and solve a diversity of problems.

Thinking tools such as structure of knowledge diagrams (\rightarrow p. 159 ff.) and analogy maps (\rightarrow p. 155 ff.), as well other **pedagogical approaches** that foster conceptual thinking and transfer of learning (\rightarrow p. 50, 53) support students in the development of interdisciplinary thinking.

Critical Thinking

Critical thinking is the ability and attitude to question norms, practices, and opinions; to reflect on one's own values, perceptions, biases, opinions, and actions.

Understanding human behaviors such as **fast and slow thinking** (\rightarrow p. 110 ff.), **cognitive biases** (\rightarrow p. 113), **moral intuitions** (\rightarrow p. 115 ff.), **social norms** (\rightarrow p. 85) and **imitation biases** (\rightarrow p. 13), as well as the practice of **psychological flexibility** skills (\rightarrow p. 127) can contribute to the development of critical thinking skills.

Self-regulation Competency

Self-regulation competency includes the abilities to understand and cope flexibly with one's feelings, thoughts and desires; to be resilient in the face of adversity; to learn and grow throughout life; and to continually evaluate and further motivate one's actions towards goals and values.

This competency is closely related to the concept of **psychological flexibility** (\rightarrow p. 127) as advanced within the field of contextual behavioral science, and as such, concepts and methods developed by this field can support educational content and methods in the service of developing student self-regulation competency.

Thinking tools such as the **Noticing Tool** (\rightarrow p. 153 f.), exploring the **concepts of values** (\rightarrow p. 128), **emotions** (\rightarrow p. 109), **fast and slow thinking** (\rightarrow p. 110 ff.) and its relation to growth mindset, or the origins of **human language and symbolic thinking** (\rightarrow p. 126), can support students in relating flexibly to their experiences and orienting their behaviors towards goals and values.

Cooperation Competency

Cooperation competency includes the abilities to reflect on and facilitate collaborative and participatory group cultures; to understand, respect, and relate to the needs, values, perspectives, and actions of others (empathy, perspective taking) across different socio-cultural backgrounds; to negotiate shared goals and values; and to deal with conflicts in a group.

Exploring the **evolution of cooperation** particularly in the human species (\rightarrow p. 75 ff.), using **Payoff matrices** (\rightarrow p. 149 ff.) to understand the role of **social dilemmas** in undermining cooperation, and applying **principles that tend to foster cooperation** (\rightarrow p. 97) in human groups can help students develop the understandings and skills underlying cooperation competency.

Intercultural Competence

Intercultural competence includes the ability to be aware of one's own cultural context; to understand the influence of culture on human behavior, cognition, values, and beliefs; and to be sensitive to and interact appropriately with humans across different cultures.

Developing intercultural competence can be supported by exploring the **cultural diversity** (\rightarrow p. 83 ff.) of human behavior and cognition, and by exploring the complex causes of human behavior, in particular causes in the cultural evolutionary history.

Evaluation Competency

Evaluation competency includes the abilities to understand and reflect on the norms and values that underlie one's opinions and actions; and to negotiate shared values, principles, and goals in a context of conflicts of interests and trade-offs, uncertain knowledge, and contradictions.

The development of evaluation competency can be supported by **explicit reflections on the concept of "values"** (\rightarrow p. 128) and related behavioral concepts, as well as regular clarifications and reflections on personal and shared values, e.g. with the help of the **Noticing Tool** (\rightarrow p. 153 f.).

Future Thinking

Future thinking includes the abilities to reflect on, understand, and evaluate multiple future scenarios and their effects on behavior, well-being, and sustainability; to create and communicate one's own visions for the future and identify underlying values and assumptions; to develop goals and action plans for realizing future visions; and to deal with risks and changes flexibly.

The development of future thinking skills can be supported by students' understanding of the role of future thinking (or "mental time travel") (\rightarrow p. 122 f.) in human evolution and behavior, its relation to morality, creating shared narratives and values, and in motivating individual and collective action.

Intellectual Humility

Related to critical thinking, metacognitive competency and self-regulation competency, **intellectual humility** involves the abilities to be aware of the origins, changeability, and limits of one's opinions and knowledge, and to be open to others' ideas and their values for advancing learning and understanding.

Exploring concepts such as **cognitive biases** (\rightarrow p. 113), or using the **Noticing Tool** (\rightarrow p. 153 f.) to become aware of and accept uncomfortable thoughts and feelings when facing uncertainty or encountering other ideas, can help students develop intellectual humility.

Growth Mindset

Growth Mindset involves an understanding of the human brain and of human knowledge and behaviors as modifiable and shaped by experience; as well as an attitude and ability to learn and grow throughout life even in the face of failures and setbacks.

We regard the concepts of Growth Mindset vs. Fixed Mindset as developed in educational research¹ as adjacent to concepts of **psychological flexibility** (\rightarrow p. 127) vs. psychological inflexibility as developed within the field of contextual behavioral science. As such, the development of Growth Mindset can be supported by methods developed for the promotion of psychological flexibility, such as mindfulness, openness to and acceptance of experiences, values clarification, and committed action even in the face of uncomfortable experience.

Community Science Competency

Community Science competency includes the abilities to use scientific concepts, methods, workflows, practices, as well as ethical standards with the aim to understand and improve one's own communities towards shared valued outcomes.

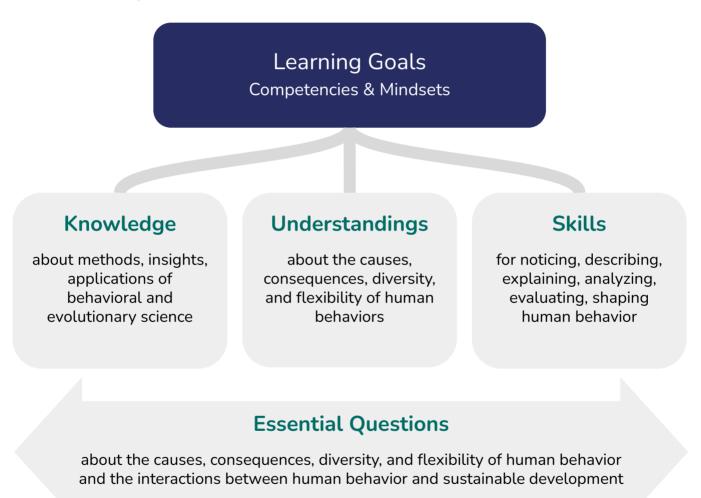
Our **Community Science Lab** (\rightarrow p. 161 f.) supports students in acquiring and applying understandings and skills underlying Community Science Competency.

Design Thinking

Design thinking includes the understanding that innovation is an iterative and often collaborative process (\rightarrow p. 136); and the abilities to analytically and creatively design solutions, tools, interventions etc. through iterative processes of context and needs assessments, ideation, prototyping, experimenting, evaluation, and redesign.

Learning Goals Knowledge, Understandings, Skills

We hypothesize that learners' abilities to metacognitively notice and develop these competencies in a self-directed manner is strengthened by deeper conceptual understandings of human behavior, and by practicing and experiencing adaptive flexibility. They are thus supported by a set of further learning goals, including knowledge, understandings, and skills. The elements of our educational design concept (\rightarrow p. 38 ff.) specifically aim to foster these understandings and skills in learners.



The learning goals on the following pages serve as examples and as a compass for teachers and students to focus on. A variety of sub-goals can be formulated from these overarching learning goals for particular lessons and units. Similarly, a variety of more specific sub-questions can be formulated from overarching essential questions for particular lessons and units.

Learning Goals Knowledge

Students will know about the various methods, research questions, central insights, and applications of interdisciplinary behavioral sciences.

Students should get to know the research and improvement methods with which we can investigate the causes and consequences of human behaviors, including the effects of certain conditions and interventions on human well-being and sustainable development. The Content Anchors (\rightarrow p. 41 ff.) of our design concept integrate such methods, including comparisons with other species, developmental psychology, cross-cultural research, experiments, computer models and case studies of sustainable resource use.



Learning Goals

Understandings

Students will understand that...

1 Our everyday behaviors and experiences have many causes, including developmental, historic, and evolutionary origins.

Students should gain a deeper understanding of the complex causes of our behaviors, especially since rather simplistic notions about causes of behavior have pervaded our culture and folk theories - from genes, to intentions, to dispositions such as "that's just the way he is/they are/I am". Reflecting on and understanding the many causes of behaviors and their interactions will help students better understand and accept themselves, their fellow humans, and their world. It will also help students explore ways to shape behavior, culture, and their world towards what they care about.

2 Humans have been shaped by biological and cultural evolution to have a capacity to cooperate and a need for social belonging.

Students should understand that we humans are a highly cooperative social species, especially since this notion might go against common cultural knowledge, which may be partly due to outdated conceptions of evolutionary theory and economics, or due to the "invisibility" of everyday cooperation and an overemphasis on violence, competition, and conflict in the media. Students should come to an understanding about why, how, and under what conditions we humans are able to cooperate and express our prosocial motivations, so that they are equipped to use this knowledge to foster cooperation and a sense of belonging in the groups and communities they are a part of.

3 Our everyday behaviors can have many consequences, some of which may be intended or unintended, and some of which may expand into scales of distant time or space in the future.

Students should understand that consequences of behaviors go beyond what is immediately observable and beyond the next moment. Particularly, consequences of behaviors can emerge from complex social interactions, such that no individual intention can account for the specific outcome. Consequences and causes are also often linked in feedback loops, such that consequences can become new causes, and habits, norms, or other behavioral and cultural structures might emerge and become more and more difficult to change. This understanding will help students assess the potential consequences of their actions or specific solutions across multiple scales.

4 The (cultural) evolution and development of human behavior is relevant to the sustainability dilemmas of today.

Students should understand that to address the sustainability challenges of our time and of the future, we can and should use insights about the human condition, including about the complex causes and consequences of our behaviors, about our capacity for cooperation and cultural flexibility, and about what humans need to thrive.

Learning Goals Skills & Thinking Tools

Students will be able to ...

1 ... use **Tinbergen's questions** as a tool to explore complex causality of human behavior.

Students should become familiar with the different questions that can be asked regarding the causes and variation of human behavior. Students should form a habit of asking questions about the role of evolutionary and cultural history, socio-economic context, an individual's development and experiences, and immediate circumstances in causing observed human behaviors, as well as the costs and benefits that humans might experience from a behavior in their circumstances and in relation to their goals and values. Tinbergen's Four questions (\rightarrow p. 140 ff.) are a helpful heuristic for this set of questions that can be made explicit to students.

2 ... construct **causal maps** to represent causal relationships between conditions, behaviors, and other factors in the development of populations and social-ecological systems.

Causal maps (\rightarrow p. 143 ff.) are an effective tool used both in science and education to identify and reflect on the complex causality of various phenomena. Through the repeated use of causal maps in the classroom, students can develop an intuitive understanding of otherwise abstract causal relationships, including feedback loops, delays, emergent outcomes, and leverage points.

3 ... represent and take perspective on the possible motivations and outcomes (costs and benefits) of human behaviors with the help of **payoff matrices**, and identify the scale of social interactions and possible social dilemmas.

Payoff matrices (\rightarrow p. 149 ff.) are an effective tool used in behavioral and evolutionary sciences to reflect on the (possible) proximate causes and emergent outcomes of behaviors in social interactions. Social interactions, particularly those that represent a dilemma between individual and collective interest, are at the center of our everyday experience and of most problems of sustainable development. The concepts of social interactions and social dilemmas can be engaged through the use of payoff matrices.

4 ... be mindful of their own experiences and behaviors in the present and orient their behaviors towards valued living, with the help of tools such as the **Noticing Tool**.

Becoming mindful of the diversity of their inner and outer behaviors helps students link behavioral concepts to their own everyday experience. Using tools of behavioral science such as the Noticing Tool (\rightarrow p. 153 ff.) can help students in noticing and interpreting the functions of their behaviors in relation to their values and well-being.

Learning Goals Skills & Thinking Tools

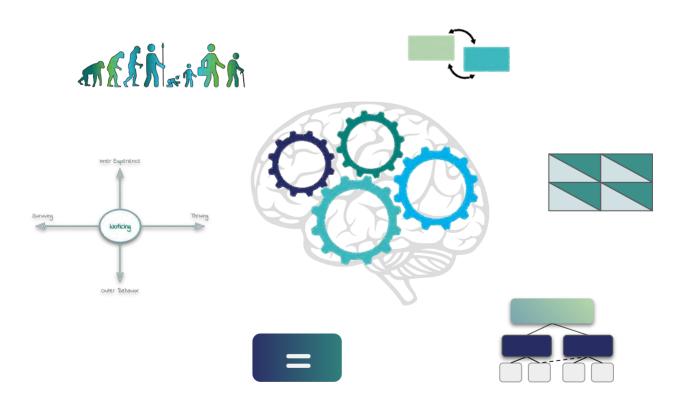
Students will be able to ...

5 ... analyze and compare phenomena (e.g. models, experiments, species, behaviors, societal events, case studies, real world sustainability issues) by overarching processes and principles with the help of **analogy maps**.

Regular engagement with analogy mappings across content helps train students' understanding of the nature of higher-level principles studied in models, experiments, or across case studies in biology and society. Analogy maps ($\rightarrow p. 155$ ff.) are therefore a great way to practice abstract thinking, interdisciplinary thinking, and transfer of learning skills.

6 ... map the structure of knowledge within a discipline or across disciplines, in a curriculum, or in their own mind, made up of abstract concepts and principles as well as specific phenomena, with the help of **Structure of Knowledge diagrams**.

Similar to analogy maps, structure of knowledge diagrams help train students' understanding of the nature of higher-level principles studied in models, experiments, or across case studies in biology and society. Structure of knowledge diagrams (\rightarrow p.159 f.) are therefore a great way to practice abstract thinking, interdisciplinary thinking, and transfer of learning skills.



Learning Goals Essential Questions

Essential questions serve to guide teachers and students in their teaching and learning throughout a unit spanning various lesson materials, or even throughout their schooling. Good essential questions help students develop their understandings and encourage them to make connections between lesson contents and the real world, or to reflect on how to use their understandings to solve real-world problems. Essential questions can be used as prompts to get initial student ideas and for (self-, peer-, teacher-) assessments of their learning. The following are higher-level questions that can be adapted to learning about particular human behavioral traits and contexts.

What are the causes and consequences of an observed behavior?

This question engages students in developing their broad understanding of causes and consequences of behavior. Adapt it to specific observed behaviors and specific types of causes or consequences in lessons.

Examples: Are humans born with a sense of fairness? How does our human sense of fairness develop? How does culture influence our sense of fairness? What motivates humans to share resources with others? Which conditions of this experiment made humans cooperate less?

What are the similarities and differences between humans and other species? Why do these differences and similarities exist?

These questions engage students in developing their understanding about evolutionary causes of human behavior as well as deeper conceptions about specific traits.

Examples: Are humans the only species that care about fairness? Are humans the only species that use and make tools? What is the difference between culture in humans and culture in other species? What is the difference between how humans cooperate and how other animals cooperate? Why are humans able to cooperate in these unique ways?

What are the similarities and differences between humans today and our ancestors? Why do these differences and similarities exist?

These questions engage students in developing their understanding about evolutionary and historic cultural causes of human behavior, and lets them reflect on potential challenges of mismatch.

Examples: How is the natural, social, and cultural environment that most humans live in today different from the environment that humans lived in throughout evolutionary history? How is education today different from how humans taught and learned throughout our evolutionary history? Why do we live and learn differently today, and what challenges and opportunities might this bring for well-being and sustainable development?

Learning Goals Essential Questions

What are the similarities and differences between all humans today, and why do these similarities and differences exist?

These questions engage students in developing their understanding of developmental and socio-cultural causes of human behavior, builds their sense of common humanity, empathy, perspective taking, and acceptance of diversity.

Examples: Do you think all humans care about fairness? Why, or why not? Why might humans across cultures behave differently in this experiment? Why might 2-year old children behave differently than 4-year old children in this experiment?

What are the similarities and differences in the conditions and observable behaviors of a behavioral experiment and the conditions and observable behaviors in the real world?

This question engages students in developing their abstract thinking and transfer skills, lets them reflect on the rationale behind specific behavioral experiments, and encourages them to critically assess the transferability of insights to other contexts. It also reinforces their understanding about how proximate factors influence human behaviors.

Example: How do the conditions and observable behaviors in the Public Goods Game $(\rightarrow p. 91 \text{ f.})$ relate to the challenges of addressing climate change?

What are the similarities and differences between different sustainability problems in the world and at different levels of society?

This question engages students in developing their understanding of the common and similar causes of various sustainability problems, often involving a number of human behavioral and cultural as well as ecological factors and interactions, and ways to address them.

Examples: What are the similarities and differences between the challenges of sustainable forest resource use in a small village and the challenge of global climate change? What are the similarities and differences between climate change and a global pandemic?

What are the similarities and differences in the evolution of species and the present and future evolution of humanity?

This question engages students in developing their understanding of core causal evolutionary processes that can be used to help explain, and ultimately shape, the changes they see in the world around them.

Examples: How are cultural traits transmitted? How do new behaviors and technologies come about? Why do unsustainable behaviors spread?

Learning Goals Essential Questions

What are important conditions for humans to cooperate towards common goals?

This question engages students in developing Understanding 2 (\rightarrow p. 32), that is, exploring the how, when, and why of human cooperation. This question represents an important research program in behavioral and evolutionary science that is explored through a variety of methods and can be revisited across content.

What research methods do evolutionary anthropologists and behavioral scientists use to understand human behavior?

This question engages students in developing their knowledge of specific research methods and what questions they allow us to answer about human behavior.

How do our behaviors impact the world today?

This question encourages students to link specific human traits and behavioral concepts to events in history or in the present, or to specific problems of human well-being and sustainable development, locally and globally.

Examples: Can you think of current events in society in which our human sense of fairness plays a role? How does the human tendency to imitate others affect the spread of sustainability-relevant behaviors? How do our cognitive biases relate to the spread of misinformation on social media?

How can we use our understanding about human evolution and behavior to shape our world towards a preferred future?

These questions provide opportunities for students to reflect on and discuss what we can do to deal with certain human traits in a way that does not lead to negative consequences for ourselves, others, and our environment; and how we can use our understanding about human behavior to address real-world challenges.

Examples: What can we do to deal with our tendency for ethnocentric thinking so that it will not have negative consequences for ourselves and society? What can we do as individuals, in the school, or as a community? How can we change people's motivation in our community to be more physically active? How can we use the human tendency to imitate others to promote the spread of sustainability-relevant behaviors? How can we use our understanding about the origins and diversity of our human sense of fairness to assure fair distribution of tasks and outcomes in our next project group work? How can we use our understanding about the human need for social belonging to increase human well-being in our community?



Our educational design concept aims to help students and teachers develop the learning goals outlined in the previous pages, particularly the skills to reflect on the causes and consequences of everyday human behaviors, and to transfer these skills to their own lives and to diverse sustainable development issues.

The strength of the educational opportunities provided by evolutionary, behavioral, and sustainability sciences lies in the rich interdisciplinary nature of their core concepts, transferable principles, methods, and skills, enabling interdisciplinary discourse, and supporting engagement in the complex problems of human society.

For educators to leverage these opportunities, we need to first **identify the key concepts, principles, methods, and skills that characterize these fields**, and to identify a diversity of **pedagogical approaches** best suited for supporting specific learning processes.

Our design concept integrates all these elements and thus aims to support you in adapting these ideas to your own teaching aims and school context. In this regard, it is important to consider that to achieve deeper understandings on the nature of human behavior and sustainability, isolated lessons are not enough. Rather, it is worthwhile to think on several levels, including on the level of units, grades, subject-specific curricula, as well as coherence across subjects and interdisciplinary learning opportunities.

Reflecting on our understanding of human evolution and behavior

Design Concept Engaging students in school improvement and sustainable development What kinds of **content**, **tools**, and **pedagogical approaches** can help students and teachers develop the **skills to reflect** on the causes and consequences of everyday **human behaviors**, and **transfer** these understandings to **sustainable development** issues?

Design Principles

Overarching principles for the identification of content and teaching methods for exploring human behavior

Content Anchors

Cross-cutting content anchors reflect the methods and fields of inquiry of evolutionary, behavioral, and sustainability science. From these, we can identify content for exploring concepts and essential questions around human evolution, behavior, and sustainability.

Thinking Tools

Thinking tools are used across diverse lessons to develop the skills that evolutionary, behavioral, and and sustainability scientists use to analyze the causes and consequences of human behavior as well as the complex relationships within social-ecological systems.

Pedagogical Approaches

Guidance for integrating multiple pedagogical traditions and learning processes in teaching practice

Design Principles

Higher-level guidelines for identifying teaching content and methods for unit or lesson design

Focus on Human Behaviors

Focus on the aspects and everyday experience of human behaviors relevant to human well-being and sustainable development (e.g., prosociality and cooperation, sense of belonging, curiosity and creativity, learning and teaching, intuitions, language, morality, empathy and compassion, sense of fairness, perspective taking, flexibility, self-control, goals and values, needs, health and well-being). *Focusing on the behavioral aspects of societal phenomena helps students relate to these phenomena and understand their causes and solutions*.

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: What roles do immediate internal and external factors, individual development, and cultural and evolutionary history play as causes of an observable human behavior? Why do these patterns of behavior exist compared to other possibilities? What consequences do behaviors have for individuals and their environment, in the short-term and in the long-term? Diverse thinking tools such as Tinbergen's questions, causal maps and payoff matrices help in reflecting on these questions. *Exploring complex causality helps students understand and evaluate solutions*.

Teach for Transfer

Ensure that students can **transfer** understandings **critically** to novel phenomena, everyday experience, and relevant problems of sustainable development across multiple scales and contexts, with the help of analogies, analogy maps, and other thinking tools. *Teaching for transfer requires the iterative exploration of diverse contexts through the lens of overarching concepts and principles*.

Content anchors

Content anchors help us explore concepts and essential questions around human evolution, behavior, and sustainability.



Content Anchors

Content anchors help us explore concepts and essential questions around human evolution, behavior, and sustainability.



Cross-Species Comparisons

What can we learn from other species about human evolution, behavior, and sustainability? Comparing the characteristics of humans and other species helps us understand the evolutionary causes of human behavior and the conditions that foster cooperation and sustainability. $\rightarrow p.55$ ff.



Child Development

What can we learn from children about human evolution, behavior, and sustainability? The development of social and cognitive skills in the course of a lifetime can help us understand the evolutionary and developmental causes of human behavior and the origins of our everyday experience. $\rightarrow p. 66$ ff.



Ancient Ancestors

What can we learn from our ancestors about human evolution, behavior, and sustainability? Exploring the characteristics of our ancestors, their living conditions, and the things they left behind gives us clues about the evolutionary causes of human behavior and the importance of collaboration and collective learning in the history of our species. \rightarrow p. 72 ff.



Cultural Diversity

What can we learn from the diversity of human cultures about human evolution, behavior, and sustainability? Studying the behaviors and cultures of humans around the world helps us understand what all humans have in common and how flexible we are as a species. $\rightarrow p. 83$ ff.

Content Anchors

Content anchors help us explore concepts and essential questions around human evolution, behavior, and sustainability.



Cooperation Games

What can we learn from cooperation games about human evolution, behavior, and sustainability? Cooperation games help us to investigate the causes, variations, and consequences of human behavior in social situations. \rightarrow p. 88 ff.



Governing the Commons

What can we learn from communities around the world about human evolution, behavior, and sustainability? Exploring diverse sustainability dilemmas in the world helps us to identify the conditions and behaviors that play a role in the sustainable development of communities and their environments. \rightarrow p. 95 ff.



Computer Models

What can we learn from computer models about human evolution, behavior, and sustainability? Computer models allow us to explore the processes that shape our own behaviors and the evolution of social-ecological systems. \rightarrow p. 98 ff.



Our Mind

What can we learn from our own thoughts and intuitions about human evolution, behavior, and sustainability? Noticing and understanding the causes of our perceptions, intuitions, and beliefs helps us to engage with them more flexibly, change perspective, and learn from each other to achieve shared goals. \rightarrow p. 105 ff.



Global Sustainability Goals

How can we transfer insights about human behavior and evolving causal relationships in social-ecological systems to individual, local, regional, and global sustainability issues? How can we use these understandings to solve real world problems? \rightarrow p. 130 ff.

Thinking Tools

A diversity of thinking tools can support the development of overarching understandings and skills around human behavior.

Tinbergen's Questions

Our behaviors have many causes, from immediately prior factors, to events in our individual past, to factors in our cultural and evolutionary history. With the help of content anchors, we can explore these different kinds of causes. Tinbergen's questions are a helpful heuristic for exploring and sorting these different types of causes. $\rightarrow p. 140$ ff.

Causal Mapping

The evolution and development of our behaviors, as well as the sustainable development of social-ecological systems, cannot be attributed to single causes or linear cause-effect relationships. Rather, they are shaped by complex causal relationships. The construction and discussion of causal maps in the classroom cultivates in students and teachers an understanding about such complex causal relationships in different phenomena. \rightarrow p. 143 ff.

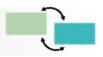
Payoff Matrices

Evolutionary biologists, economists and sustainability scientists sometimes represent the costs and benefits that people (or other animals) get from a behavior in a social situation through a so-called **payoff matrix**. Using payoff matrices in the classroom helps us **reflect on the possible motivations for and consequences of behaviors** in particular situations. \rightarrow p. 149 ff.



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Thinking Tools

A diversity of thinking tools can support the development of overarching understandings and skills around human behavior.

Noticing Tool

The Noticing Tool is a simple matrix that helps us **be aware of and interpret our experiences and behaviors** in the present and to orient our behaviors **towards valued living**. It can thus be useful in developing a variety of competencies and attitudes in students, including **self-regulation**, evaluation, growth mindset, cooperation, and intellectual humility. \rightarrow p. 153 ff.

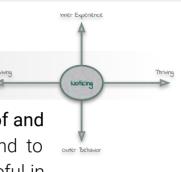
Analogy Mapping

Because all learning involves the transfer of concepts and principles between phenomena, analogies play an important role in science and education. They allow us to illustrate abstract concepts, to use our understanding of familiar phenomena in order to understand new phenomena, and to derive overarching principles and theories. The discussion of analogies and use of analogy maps in the classroom fosters networked learning and learning transfer. \rightarrow p. 155 ff.

Structure of Knowledge Diagrams

Both our own knowledge about the world and scientific ideas are organized in a structure that connects generalizable concepts and principles to specific phenomena or facts. Structure of Knowledge (SoK) Diagrams help us reflect, visualize, and critically expand and modify this structured knowledge of the world. Especially for exploring inter- and transdisciplinary phenomena like human behavior and issues of sustainable development, SoK diagrams can be a useful tool to promote interdisciplinary, networked, and pluralistic thinking, metacognition, and learning transfer. \rightarrow p. 159 ff.









Using best practices for lesson and unit design

In the 21st century, educators have become aware that the pedagogical approach of direct instruction and transmission of information, which has been prevalent in formal schooling in the 20th century, is not sufficient for developing the kinds of competencies (\rightarrow p. 25 ff.) that are necessary for students to succeed in life and to have a positive influence in their communities .

Calls for more situated, authentic, experiential, transformative pedagogical approaches have therefore had an influence in educational innovation movements in the last decades. Education for Sustainable Development (ESD) practice and programming has also been influenced by this emphasis on experiential, transformative education¹.

Unfortunately, discourse in education is often characterized by a battle between the two camps, i.e. educators that swear by the value and need of direct instruction on the one hand, and educators that swear by the value and need of project-based, experiential, authentic experience and critical reflection.

A "multi-pedagogical" or "reflexive pedagogy"² view considers all of these different pedagogical approaches as playing important roles in learning - this is because learning involves different processes - different ways of knowing - including direct experience, conceptual understanding, critical reflection, and appropriate and creative application of the learned ideas, all of which can best be cultivated by different pedagogical approaches. The point of good education is not to choose one over another and disregard the rest, but to choose the right approach for the right moment in the learning process, and to weave them all together in the best way such that learning is strengthened and motivating for all learners.

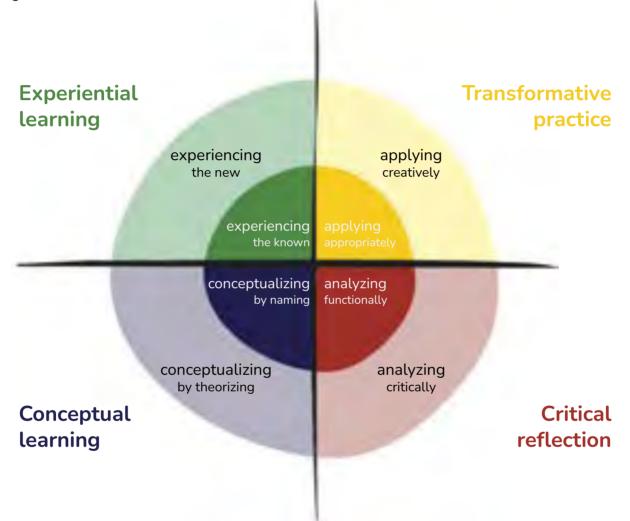
"Pedagogy is a range of different 'things you do to know', a repertoire of learning activity types, including activity types that have their genesis variously in didactic and authentic pedagogy. (...) Our suggestion to teachers whose practices by and large fall into one tradition or the other, is to extend your repertoire— which many excellent teachers, in any event, instinctively do anyway."

Cope & Kalantzis (2015), p. 14

¹ UNESCO (2020)

Using best practices for lesson and unit design

The different knowledge processes that can be involved in learning and that require different pedagogical approaches are presented in the following diagram¹.



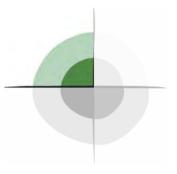
Reflecting on our experience of human behavior, understanding and analyzing its variation, causes, and consequences, and applying our understanding to problems of everyday life and sustainable development, all involve these different knowledge processes.

In the following pages, we highlight each of the knowledge processes as well as activities, content, and questions that target each of these within the theme of human behavior.

Using best practices for lesson and unit design

Experiencing ...

- the known learners reflect on their own familiar experiences, interests, and perspectives.
- the new learners observe or take part in something that is unfamiliar; they are immersed in new situations or contents.¹



Because human behavior is at the center of our lives and everyday experience, many opportunities exist to let students bring this everyday understanding into the classroom when exploring a particular set of behaviors. For example, through various reflection and discussion questions:

- Think of a situation when you felt treated unfairly. How did it make you feel?
- Do you think all humans care about fairness? Why, or why not?
- Might humans have different views about what is fair in a particular situation? Why, or why not?

Through the methods and insights of behavioral science, many opportunities also exist that allow students to **experience new aspects of human behavior** in the classroom. **Content anchors** such as classroom games, computer simulations, behavioral experiments and observations across species, ages, or cultures, archeological findings, and even exploring what their own mind does in the moment. **Texts, images, videos, art**, or social **media content** can also serve to expose students to particular aspects of what humans do, think, and feel.

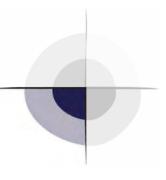


¹Adapted from Cope & Kalantzis (2015, 2020)

Using best practices for lesson and unit design

Conceptualizing ...

• **by naming** – learners acquire new concepts and/or extend, deepen, and enrich their prior understanding of known concepts, by exploring examples and attributes and constructing definitions.



• **by theory** – learners make generalisations by connecting concepts in relationships¹

Even though human behavior is at the center of our lives and everyday experience, we might not have an explicit, complex, and deep understanding about what human behavior actually is (and what it is not), how it is caused, how and why it varies among humans, or how we can change it towards what we actually care about. In order to reflect on human behavior, students need to gain an understanding of core concepts, such as:

- What is human behavior? What are some examples, and non-examples, of human behavior? What characterizes human behavior?
- What is sustainability?
- What is evolution? What is cultural evolution?
- What is fairness?

Furthermore, students need to gain an understanding about how concepts relate to each other to form overarching generalizations and principles, such as:

- How does human behavior impact sustainable development?
 - How does our human sense of fairness impact sustainable development?
- How do our behaviors impact the cultural evolution of our species?
- What conditions allow and hinder humans to cooperate towards common goals?
- How does our evolutionary past impact our behaviors today?
- How does our experience and learning impact our behaviors today?

Using best practices for lesson and unit design

Box 4. Teaching for conceptual understanding

Teaching for conceptual understanding¹ is an educational approach designed to help students achieve deeper and more transferable understandings of concepts and general principles within a topic, in contrast to the mere memorization of topic-specific facts. This is because facts and knowledge about isolated topics alone do not transfer to new phenomena and are thus not enough if the aim is to cultivate in students competencies such as problem-solving, critical thinking, creativity, collaboration, and perspective-taking, as well as the ability to apply such competencies in novel contexts. Furthermore, when students understand and transfer concepts and principles, i.e. build up a *structure of knowledge* (\rightarrow p. 150 f.) in their minds, facts around particular content will also become much easier to learn and retain than through rote learning alone.

Some important elements and steps for designing concept-based units and lessons are:

- Identification of a set of concepts, generalized principles, and skills that characterize a subject area or topic. These transfer across examples, time, and cultures. These are also the understandings and skills we aim for students to develop as they explore various content throughout the unit.
- Formulation of more or less general or specific essential questions that help students to uncover and reflect on the deeper principles and generalizations in concrete examples.
- Elicit student **pre-conceptions** at the beginning of a unit or lesson.
- Provide students with various content examples to help them refine their understandings of generalized principles, transfer them to new contexts, and practice applying particular skills.
- Let students reflect and discuss how their understanding is changing and developing with every studied example, and how their understanding is relevant and significant to themselves and their world.

¹ Erickson, Lanning, & French (2017); Stern, Ferraro, & Mohnkern (2017)

Using best practices for lesson and unit design

Analyzing ...

- functionally learners analyze logical connections, cause and effect, structure and function.
- **critically** learners evaluate their own and other people's behaviors, perspectives, interests, and motives.¹

Many of our learning goals (\rightarrow p. 30 ff.) are structured around the ability of students to analyze and reflect on the causes and consequences of human behavior, the functions that particular behaviors have for humans in relation to their goals and values and in the context of their particular environment.

Analyzing causes and consequences of human behavior is also a core aim of the behavioral sciences. Our collection of **thinking tools** (\rightarrow p. 44 f., 139 f.) reflect some of the tools that scientists use for this analysis and that students can equally use when analyzing human behaviors across contexts. For example:

Tinbergen's questions: a set of four broad questions that can help to map out the space of different causes that we need to explore in order to understand why humans behave the way they do in a particular situation (\rightarrow p. 140 ff.)

Causal mapping: a simple tool that lets students collect, visualize, discuss, analyze, and reflect the different causal relationships and complex interactions between human behaviors and the environment (\rightarrow p. 143 ff.)

Payoff matrix: a tool to let students reflect on the beliefs, feelings, and goals underlying human motivations to behave in a certain way in a certain situation, and the emergent outcomes their behaviors create for themselves and others (\rightarrow p. 149 ff.)







Using best practices for lesson and unit design

Applying ...

- **appropriately** learners apply new learning to real world situations and test their validity.
- **creatively** learners make an intervention in the world which is innovative and creative, or transfer their learning to a different context.¹



Students' ability to transfer and apply new learning appropriately to new contexts is one of the core aims of education in general, and is represented by one of our overarching design principles (\rightarrow p. 40).

We want students to be able to apply the conceptual understandings that they develop around the nature of human behavior to situations in their everyday life, and to real-world problems of sustainable development.

Thinking tools like **analogy maps** (\rightarrow p. 155 ff.) can help students in reflecting on the transfer of general principles and processes across a wide range of contexts and domains.

=

Finally, we want students to use their understanding of human behavior to identify, develop, and evaluate interventions and solutions to real-world problems.

For example:

- Students create norms for their next project group work to assure that all members of the group are motivated and feel treated fairly, based on their understanding of the conditions that foster cooperation.
- Students develop and implement a community science project to explore ways of increasing well-being of teachers and students at their school, by incorporating and deepening their understanding of human well-being.



¹ Adapted from Cope & Kalantzis (2015, 2020)

Box 5. The Learning Transfer Mental Model

Educator Julie Stern and colleagues are experts in instructional strategies that help students transfer their learning to new situations. Their *Learning Transfer Mental Model*¹ shown below offers a simple framework for teachers and students to understand what it means to transfer, and to guide their learning of new concepts towards understanding complex issues. Example conceptual questions below show how we use this model for exploring the themes of human evolution, behavior, sustainability, and their connections.



Acquire

Step 1: Understand the critical attributes (traits or characteristics) of a concept by exploring your prior understanding and comparing examples and non-examples of the concept.

What is human behavior? What characterizes behavior? What are some examples and non-examples of human behavior?

What is evolution? What characterizes evolution? What are some examples and non-examples of evolution?

What is sustainability?

What is a social dilemma?

What is fairness?

What is a complex system?

What are human values?

What is mindfulness?

What is well-being?



Connect

Step 2: See how concepts are connected in relationships. Conceptual questions guide students in exploring those relationships in different situations.

How does human behavior impact sustainable development?

How does our evolutionary past impact our behaviors today?

What are the causes and functions of our moral intuitions?

How does social inequality impact human well-being?

How does the cultural evolution of technologies impact sustainable development ?

What conditions enable humans to cooperate towards shared goals?

How can mindfulness influence human well-being and sustainable development?



Transfer

Step 3: Recognize similar patterns across situations to deepen your learning. We can return to the same questions from step 2 when we encounter a new situation, often by adding more concepts to the questions.

How can we use our understanding of cultural evolutionary change to explain the prevalence of unsustainable behaviors?

What are the similarities and differences between the way our taste buds work and function, and the way that our "moral taste buds" work and function?

How does human social behavior impact a current social conflict?

What conditions enable humans to cooperate towards addressing global climate change?

How can we change the conditions in our school to increase trust, belonging, well-being, and learning?

"We need to transform the goals of teaching and learning (curriculum) and not simply change the delivery method (instruction). When we organize our curriculum through fundamental and powerful concepts, our students are able to transfer their understanding to new situations and apply it in unique ways. In this way they create something innovative and world changing, becoming the next great innovators."

Stern et al. (2017), p. 6

"It seems that the goal of all learning - not just Concept-based learning - is transfer. The key to understanding transfer is this: Facts and topics do not transfer. By this we mean that facts and topics can not be applied to a new situation. Whenever we try to apply our insights from one situation to another we are always abstracting to the conceptual level, generalizing from a specific instance to a broader rule, before our knowledge helps us unlock the new situation. Our brains are wired for this process."

Stern et al. (2017), p. 15

"There are an infinite number of instructional strategies that can be used to teach students how to make sense of our complex world. The key is to empower our students to become their own teachers. We do that through explicitly teaching them how to be conscious of their thinking and learning, to question their assumptions, to revisit what they previously understood, to make connections that help them understand how our world is organized, and to use their understanding to unlock new situations. Imagine the possibilities if more and more students are able to do this type of complex learning independently. Imagine the type of communities we could enjoy if more and more adults begin to seek understanding before judgment. We all entered this profession to help young people go on to lead meaningful and successful lives. We need to abandon the idea that this is achieved through the mere accumulation of disconnected bits of knowledge. The [Learning Transfer Mental Model] is a way of thinking about how learning occurs to help students make sense of the complexities of our world, without oversimplifying it."

Stern et al. (2021), p. 259



Humans seem to be a "strange" species....



Do other species do similar things? Why, or why not?



Humans are living beings, mammals, primates, and apes. Like all other living beings, we **need resources** to survive, grow, and produce offspring. Like all other living beings, we exist in **interaction with our environment**. Like many other social species, we **depend on our social environment** to survive and raise our offspring.

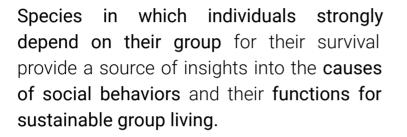
Social life, however, brings with it many challenges and the potential for conflict: How should available resources be divided? Who should contribute how much to food provision, to the care of offspring, and to other vital functions? Who decides what should be done? How do we sustain ourselves, our offspring, our livable environment?

What can we learn from other organisms and groups of organisms about how to **overcome these challenges of sustainable coexistence**? How can we translate these insights to the challenges facing our environment and our global society?

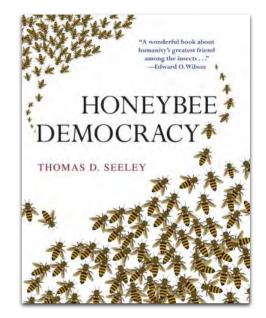


Cross-Species Comparisons

Honeybee "democracy"?



The biologist Thomas Seeley studies the behaviors of honeybees. Especially the **decision-making process in a bee colony** attracted his attention. How do thousands of bees manage to make the best possible decision about their future nesting site in an efficient way and without a leader?

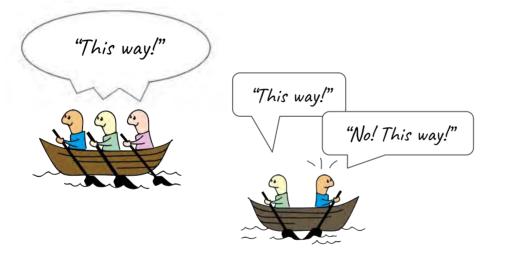


"We often think of democracy as an invention of mankind (....) But democracy needs to be understood more broadly, it is not just a form of government. We find it in a whole range of species. Look at a flock of birds that must agree on where to fly. Watch a group of geese decide when to set off in the morning. Ask a group of baboons what direction they want to go. I believe that in all these situations, there are elements of democracy, that is, whenever decisions are made by the group and not by a leader."

Seeley (2015), own translation



Due to the **division of labor** in a honeybee colony, all the bees of a colony are clearly sitting **in the same boat** (\rightarrow p. 8 f.) - their survival and reproduction depend on that of the colony. No bee can, in the long run, survive and reproduce on its own. This fact, and the fact that honeybees have a 30-million-year history, seem to indicate that this species has evolved effective ways to regulate group life. This includes decision-making about the "future" of the bee colony, even if individual bees can not actually think in terms of their preferred future.



When everyone is in the same boat, it is important to decide the direction together.

"For the members of a decision-making group to work together productively, they must have a fair amount of alignment of interests so that they are inclined to form a cooperative and cohesive unit. (...) The bees also demonstrate that a democratic group can function perfectly well without a leader if the group's members agree on the problems they face and on the protocol they will use to make their decisions."

Seeley (2010)



Cross-Species Comparisons

"The fundamental decision-making dilemma for groups is how to turn individual preferences for different outcomes into a single choice for the group as a whole. (...) [T]he study of group decision making by honeybees might help human groups achieve collective intelligence and thus avoid collective folly. Good group decisions, the bees show us, can be fostered by endowing a group with three key habits: structuring each deliberation as an open competition of ideas, promoting diversity of knowledge and independence of opinions among a group's members and aggregating the opinions in a way that meets time constraints yet wisely exploits the breadth of knowledge within the group."

Seeley et al. (2006)

Principles for democratic decision-making

- Common goal(s) or shared interests
- Low influence of a central leader
- Diverse and independent experiences and perspectives
- Open exchange of views
- Consensus building



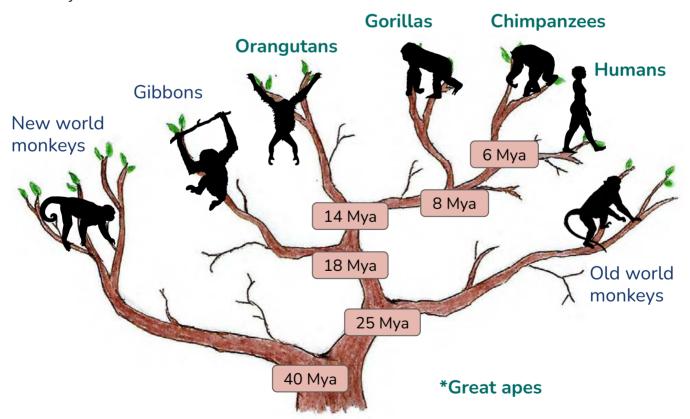
Biologists find similar principles in the organization and decision-making processes of ants and in our brains (\rightarrow p. 107) - that is, whenever populations of individuals (bees, ants, cells) have to survive together, and must therefore "decide the direction" together. It is no coincidence then, that these principles are instantiated in one way or another in a well-functioning human democracy.



Humans are primates

... and not very closely related to honeybees. With bees, we primates have in common that we live in social groups. But we primates have much **more complex and flexible social behaviors**. We have various forms of social life: some of us live in large groups, others in small groups. Compared to bees, we primates have more complex social emotions that shape our social behavior.

How are we humans different and similar to other primate species, and why? What similarities are the result of our common descent, and what similarities are the result of similar challenges in the course of species-specific evolutionary history?



Evolutionary anthropologists study the similarities and differences in the characteristics of humans and our near and distant primate relatives.



Humans are great apes

We apes have good abilities to understand our physical environment: we have good spatial perception, understand cause-and-effect relationships, we handle and use objects as tools in many ways, we can understand some of the mental states and intentions of others, and we recognize ourselves in the mirror.



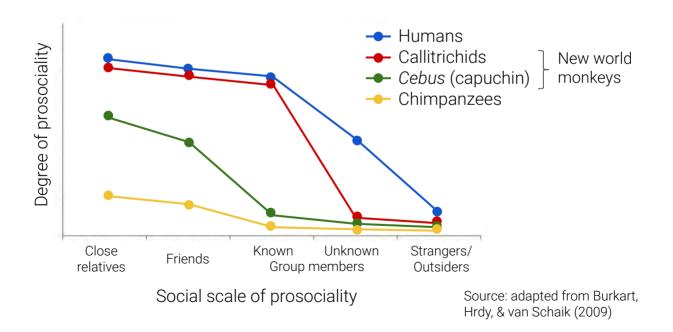
But why have we become the ape species whose behaviors and technologies are changing the entire planet today, who work together in large groups in order to change those effects, to send a few of us to the moon, to exercise aggression towards other groups in complex ways, to create art and music, or to understand our own evolution? Why is a "Planet of the Apes" fiction when it comes to chimpanzees, bonobos, gorillas, and orangutans, but a reality when it comes to our species of ape?



Cross-Species Comparisons

Humans are a highly prosocial type of primate

For biologists, **prosociality** refers to behaviors that benefit others. Spontaneous prosociality is the ability and motivation to be friendly, to tolerate others' presence, or to share things and information with others without threat or rational calculation, but rather spontaneously or voluntarily. Spontaneous prosociality is thus not tied to "intelligence" or certain cognitive abilities, but to a particular **social temperament**. When biologists compare the extent of prosociality in different primate species, they find that those species that live in groups and collaboratively raise their offspring have a pronounced prosocial temperament. Apparently, a prosocial temperament has an important function in sustaining groups in which everyone is **"in the same boat"**.



While there is a lot of variation in prosociality across individuals and groups within species, it appears that compared to other primates humans have a strong prosocial motivation, even towards unknown others.



"Here's a headline most people wouldn't bat an eye at: 'Four people were murdered in New York City today', we almost expect it. But here's a headline we're never going to see: '8,299,996 people got along in New York City today'."

Fuentes (2014)



"Humans are often eager to understand others, to be understood, and to cooperate. Passengers crowded together on an aircraft are just one example of how empathy and intersubjectivity are routinely brought to play in human interactions. It happens so often that we take the resulting accommodations for granted. But just imagine if, instead of humans being crammed and annoyed aboard this airplane, if it were some other species of ape. (...)

What if I were travelling with a planeload of chimpanzees? Any one of us would be lucky to disembark with all ten fingers and toes still attached (...). Bloody earlobes and other appendages would litter the aisles. Compressing so many highly impulsive strangers into a tight space would be a recipe for mayhem."

Hrdy (2009), p.2-3



So, while we share certain mental abilities with chimpanzees and other apes, in our prosocial temperament we are more similar to our more distant primate relatives. Even in our ability to make joint decisions in a democratic way, we seem to be more similar to honeybees than other great apes (even though the mechanisms of decision-making in bees and humans may look quite different).

"Humans are 90% chimp, and 10% bee".

Haidt (2012)

Some anthropologists suggest that the interplay between the cognitive abilities that we have inherited from our common ancestors with the other apes, and a high prosocial temperament that appears to have evolved throughout our own evolutionary history (\rightarrow p. 78 ff.), has led to the particular capabilities of our species: the ability to work together, to care for the well-being of others, to communicate, to learn from each other, and to invent new things together.

"Our hypothesis is that while chimpanzees and, perhaps, all great apes may have many of the relevant cognitive preconditions for uniquely human cognition to evolve, they lack the motivational preconditions. In humans alone, these two components have come together."

Burkart et al. (2009)

Our prosocial attitude towards our conspecifics depends very much on the extent to which we count strangers as being within "our group" (\rightarrow p. 33). As long as we have a common identity, or our perception tells us that we are "all in the same boat", it is relatively easy for us to get along with everyone in our "boat". We may, however, show a completely different set of primate behaviors if our perception tells us that we are dealing with outsiders or competitors.



Cross-Species Comparisons

Humans have culture



"Culture" has many meanings, depending on the discipline. Scientists that study other species beyond humans usually have a general definition that does not depend on human activities: Culture is all the behaviors and knowledge that are acquired and passed on within and between generations through **social learning**.¹

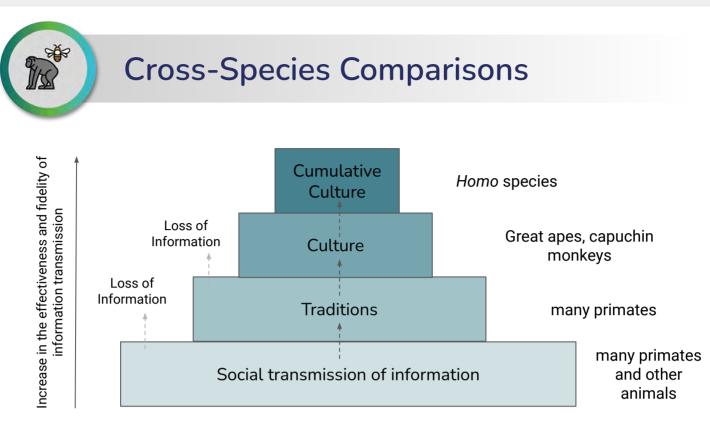
By this general definition, many species have culture, including primates but also birds, fish, and even invertebrates, because they pass on many behaviors through some form of social learning.¹

Our species has particularly good skills for social learning and imitating others, as well as for teaching and communicating complex social information, thanks to language. This allows new **ideas**, **knowledge**, **beliefs**, **technologies**, **traditions**, **norms**, and other **cultural traits** to spread and accumulate over generations in our populations. A person born today could not invent the vast majority of the important technologies of her culture during her own life, and could not acquire all the cultural knowledge through her own experience alone.

Consider for yourself: how many things do you use in your everyday life – how you live, how you move, how you communicate with others, the technologies you use, what you eat – and how much knowledge you have accumulated in the course of your life? How easy would it be for you to make these things yourself through independent learning, or to acquire this knowledge only through your own observations and experiences?

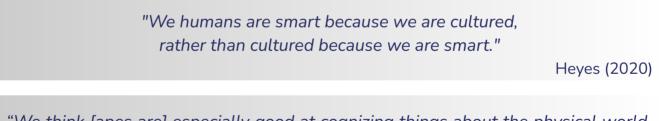
Based on this fact, anthropologists distinguish human culture from the culture of other species. They call this form of culture **cumulative culture**, from the Latin *cumulare*, which means to "accumulate", "pile up".

¹ Schuppli & van Schaik (2019)



Source: adapted from Whiten & van Schaik (2007)

Many scientists think that it is in fact this ability to accumulate, transmit, and learn cultural information that makes humans seem so much more "intelligent" than other species.



"We think [apes are] especially good at cognizing things about the physical world, understanding space and causal relations like when using tools, what causes something to move etc. They're very good at that and basically they're not that different from human children.

What makes us really different is our ability to put our heads together and to do things that neither one of us could do alone, to create new resources that neither one of us could create alone. It's really all about communicating and collaborating and working together."

Michael Tomasello (2014) Former director of the department of Developmental and Comparative Psychology, Max Planck Institute for Evolutionary Anthropology

Child Development

Questions about human nature have occupied philosophers for more than two millennia: are we born innocent angels, and growing up in society turns our nature into selfishness and deceit? Are we by nature selfish and violent, and only by education we instill a sense of justice, empathy, and morality into our children?

What are the characteristics and behaviors that characterize the *Homo sapiens* species, and what are the consequences of education and growing up in a particular social environment? These questions are examples of the **Nature vs. Nurture** debate that still is the subject of much discussion today.

Anthropologists who ask these questions are particularly interested in the **development of children in different cultures** (\rightarrow p. 83 ff.). By observing the skills and behaviors of growing children, researchers can gain insights into the evolution of our species: children show us what qualities humans exhibit before we are strongly influenced by our social and cultural environment, and to what extent the sociocultural environment and individual experiences shape the development of our perceptions and behaviors.

"Studying early childhood means learning to understand how humans have become who they are - every individual as well as all of us as a species. This understanding creates perspectives. Perspectives on the fundamental commonalities of all humans as well as the differences between individuals and cultures, on equal opportunities and health and the things that impede them."

> Daniel Haun, Director of the Department of Comparative Cultural Psychology, Max Planck Institute for Evolutionary Anthropology

Child Development

Our "genetic starter kit"¹ for social cognition and learning

- As soon as we are born into the world, and perhaps even before, our perception is focused on our social environment: faces, voices, and the emotions and actions of the agents around us attract our particular attention.
- Around the age of three months, we might already be able to perceive and distinguish whether someone behaves "good" and helpful or "bad" towards others, and we prefer the "good ones."
- Around the age of nine months, we begin to communicate in a special way with the people around us: through the use of pointing and eye contact, we discover the world together, focus our attention on common points of interest, engage in shared activities, and construct sounds or gestures together into symbols that represent things in the world. We begin to favor and pay special attention to those who resemble us in their preferences, language, and appearance.
- In the second year of life, we develop the ability to perceive the needs and preferences of others, to distinguish them from our own, and to spontaneously help them and share with them. We already begin to have a sense of the fair distribution of things. Words and other symbols become more and more important and are increasingly shaping our experience. We start to recognize ourselves in the mirror as "me".
- In the fourth year of life, we develop the ability to distinguish our present needs and mental states from those that we had in the past or might have in the future. We begin to use memories and language to develop our own conscious identity and life story.
- ✤ From the age of five, we begin to also align our behavior with social norms (→ p. 85) and to control our impulsive responses: we have learned from others what is "good," "right," "normal," and what is "bad," "wrong" and "unnormal", and we automatically incorporate these rules into our perceptions, thoughts, identities, judgements, predictions, values, and behaviors.

Child Development

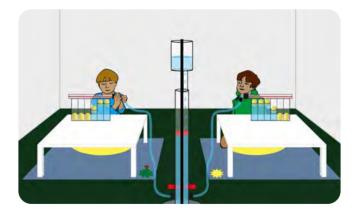
"[Our research] suggests that from very early in [development] young children have a biological predisposition to help others achieve their goals, to share resources with others and to inform others of things helpfully. Humans' nearest primate relatives, such as chimpanzees, engage in some but not all of these behaviors: they help others instrumentally, but they are not so inclined to share resources altruistically and they do not inform others of things helpfully."

Warneken & Tomasello (2009)

Studies¹ demonstrate that, through the early development of these social and cognitive abilities, children as young as six are already capable to use a shared, limited resource by talking to each other, building a common identity, establishing common rules, and sharing the resource fairly. They can prevent the "tragedy of the commons" (\rightarrow p. 7) without anyone telling them what to do, and even if they have never met before.

Apparently, it is generally easier for us humans than for our closest relatives to work together with our conspecifics, to learn from one another, and to share things - even if these behaviors may not be expressed in all circumstances.

These insights make it clear that the important question might not be "Are humans good or bad?", but "What conditions enable humans to express their prosocial tendencies?"





¹ Koomen & Herrmann (2018a,b)

Child Development

Extended childhood and education characterize our species

"[O]ur unique evolutionary trick, our central adaptation, our greatest weapon in the struggle for survival, is precisely our dazzling ability to learn when we are babies and to teach when we are grown-ups."

Gopnik et al. (2000), p. 8

In the development of all these human abilities - empathy, sense of fairness, cooperation, learning and teaching, language and symbols, thought, adopting social norms, control of our behavior - the genes we come into the world with are crucial, but they are just a "starter kit". The individual development of human beings is particularly tied to growing up in a social environment and therefore can only be understood in the context of the evolution of our culture.

"The way children have learned and been taught during millions of years has had a direct impact on how we as humans act and think. Homo sapiens cannot avoid learning and teaching. We do it by reflex. Even young children have a natural capability to teach."

Högberg & Gärdenfors (2015), p. 118

"People often seem to split the human mind into two parts: a "natural" neurologically determined part that is shaped by evolution and a "cultural" socially determined part that is shaped by learning. Studying babies makes us realize how deeply misguided these oppositions are. (...) For human beings, nurture **is** our nature. The capacity for culture is part of our biology, and the drive to learn is our most important and central instinct."

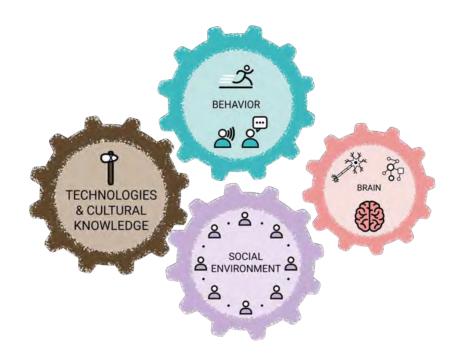
Gopnik et al. (2000), p. 7, 8

Child Development

"If you raised a child on a desert island with no social context, no teaching, not any contact to humans, their intelligence as an adult would be very similar to that of other apes. It'd be a little bit different, but [human children] have evolved to learn from others, and to communicate with others, and to collaborate with others. And if there was no one there, and no culture and no tools and no language, then that naturally human intelligence just wouldn't develop.

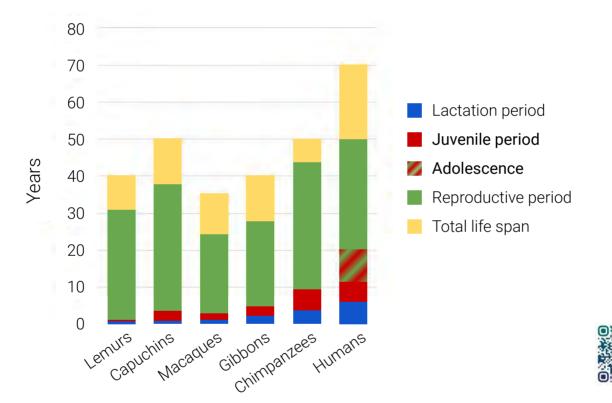
Fish are born expecting water, they've got fins and gills, and humans are born expecting culture."

Michael Tomasello (2014) Former director of the department of Developmental and Comparative Psychology, Max Planck Institute for Evolutionary Anthropology



Child Development

Compared to other primates, we humans also invest a lot in our offspring - for a very long time, children depend on the adults around them and they are given lots of time to learn. Furthermore, not only the parents, but many other people in our environment take care of us, teach us things, and provide for us. Social learning and teaching during childhood and adolescence seem to play important roles in our species.



Compared to other primates, we humans have a very long childhood, and have evolved a new phase of life: adolescence. Source: adapted from Zimmerman & Radespiel (2007, p. 1166)

The importance of childhood, social learning, and teaching in the evolution of our species provides a perspective on why *education* continues to play a central role in the future sustainable development of our species. Indeed, what children learn from their social environment today may also shape the future of our species.





How can we explain the traits and behaviors that seem to differentiate our species from others (\rightarrow p. 55 ff.), and which we humans already show in early development (\rightarrow p. 66 ff.)?

Many anthropologists, psychologists, behavioral scientists, and sustainability scientists are interested in the evolutionary history of our species, because we can only understand our present-day behaviors, needs, experiences, and cultures against the background of their evolution. We can also better tackle today's challenges to human well-being, peaceful coexistence, international cooperation, and sustainable resource use if we compare our living conditions with those of our ancestors, and if we know what factors contributed to the survival of our ancestors.

Who were our ancestors? How did they live? Were they exposed to similar challenges as we are today? How did they master these challenges? What have we inherited from them, and why?



Scientists use different names for our ancestors and distant aunts, uncles, and cousins that roamed the planet during the last 6 million years. Often, the term *Hominins* is used for this group of great apes.



Ancient Ancestors

Studying human evolution and trying to understand what happened throughout the last ~6 Mio years of our evolutionary history is much like trying to piece together a puzzle without the box top image, and with the knowledge that most of the puzzle pieces have been lost or damaged. How would you go about this? And what information would you use in this process in order to guess what the whole picture might be? At what point would you be 50% certain, 90% certain? When would you update or modify your guess?

Every fossil or archeological find adds a new piece to the puzzle. Where does it fit into the puzzle and what does it add to the overall picture that is emerging? Is it a corner piece? Does it help us to have more certainty about what is depicted in one corner of the puzzle, or what the resulting whole image might be? Or is it quite ambiguous and doesn't seem to fit anywhere in the existing patchwork, so we need to set it aside for now until we might find more pieces and clues? And what if the piece we find has been damaged?

In this regard, sensationalist headlines of a new archeological find claiming that it "changes everything we know about human evolution" might give the wrong impression that when it comes to human evolutionary science, it's all guess work and that scientific insights are just as good as any other ideas. It would be like finding a new puzzle piece and instead of looking where it fits, destroying the whole puzzle and starting it from the beginning, or not doing the puzzle at all and offering ideas about the overall image without evidence.

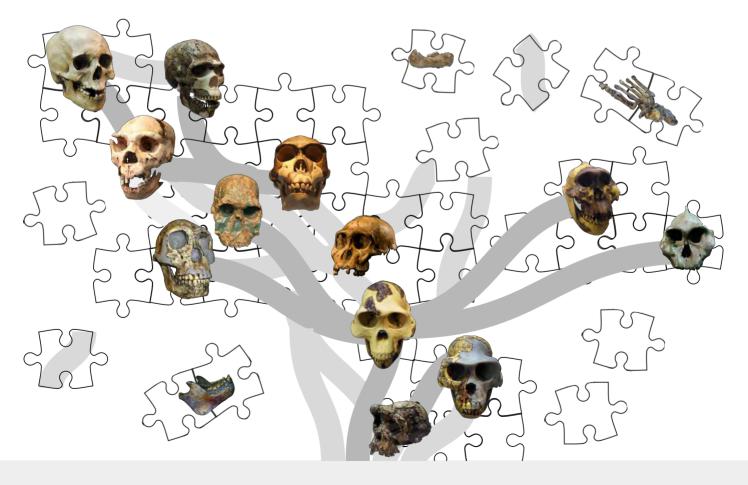
Instead, scientists have come to the conclusion that human evolution is messy, and that the family tree of hominin ancestors and distant aunts and uncles resembles more of a braided stream than a neat evolutionary tree with well defined branches of ancestry that are waiting to be discovered. We can be sure that many types of hominids existed, and that there were quite complex relations between them - they coexisted, they interbred, one was the ancestor of another, and so on. Because it is often difficult to define even a particular species, it is hard estimate the diversity of hominin types that existed.



Ancient Ancestors

Just as we can be pretty sure about the defining features of puzzle pieces, whether they are a corner or an edge, and what colors and patterns they may contain, the few puzzle pieces we find from our evolutionary past give some important and more or less unambiguous information - such as their age and the place where they were found. With a bit less certainty, they can also give us clues about the environment and lifestyle of our ancestors, such as climate, diet, or tool use, and possibly something about their look and their relationship with other puzzle pieces.

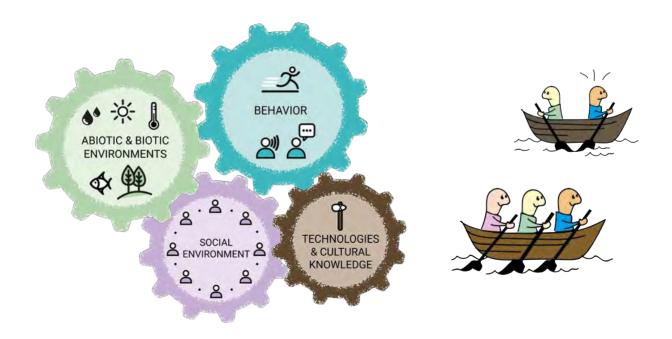
Through this process, we now have a picture of some areas of the puzzle. We have some certainty in places, while other areas remain rather blurry and empty. For example, it seems that there were several branches of hominins that went extinct. Against all odds, our species *Homo sapiens* is the only surviving hominin species.

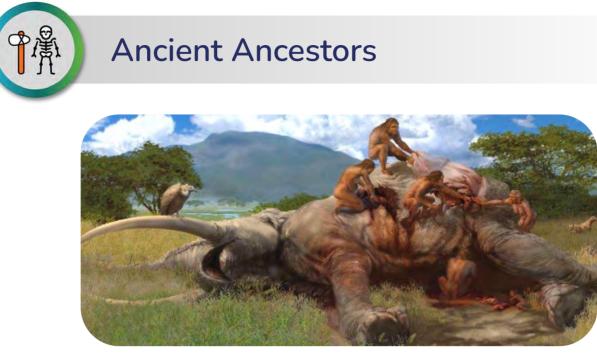




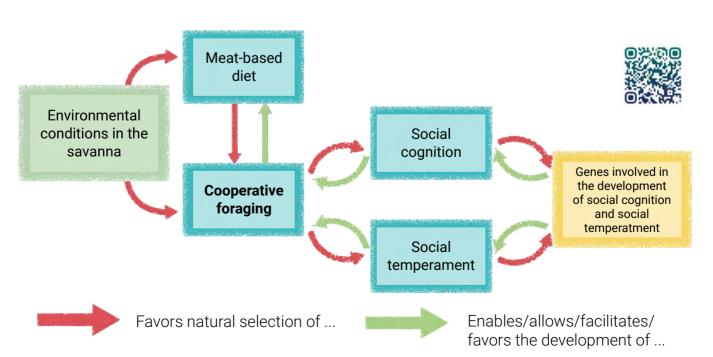
Ancient Ancestors

So while it is not easy to draw conclusions about the existence, living conditions, and behaviors of our ancient ancestors merely from isolated fossils and archeological findings, what is certain is that there have been many challenges to survival and sustaining a livelihood throughout our evolutionary history. The conditions of the natural and social environment of our ancestors led to individuals being increasingly dependent on the group for their survival - they were all **sitting in the same boat** (\rightarrow p. 8). Under these conditions, some groups had higher chances of survival and reproduction than others: namely those groups in which individuals were able to work together, learn from each other, pass on vital technologies to the next generation, share resources within the group, avoid conflicts, or solve them as efficiently as possible. These circumstances have shaped us as a species. Many of **our behaviors, motivations, and needs that are observable today** can only be explained by the fact that they have **evolved as an adaptation to group living**.





To compete with predators as primates is not that easy. Those who were able to work together in food procurement, coordinating their activities in order to achieve a common goal, and then divide the food in the group, had greater chances of survival and reproduction than others.



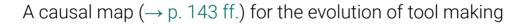
A causal map (\rightarrow p. 143 ff.) for the evolution of cooperative skills

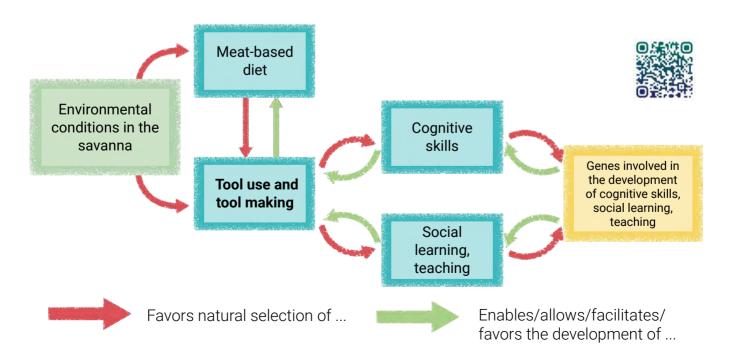


Ancient Ancestors



Making a hand-axe, fire, and other complex tools is also not that easy. Those who had good skills and motivations for social learning and teaching were better able to learn this toolmaking from others, and pass it on to others. These skills allowed the transmission and accumulation (\rightarrow p. 64 f.) of ever more complex technologies in our species.





Ancient Ancestors

Thus, evolutionary anthropologists conclude from the observations of our close and distant relatives (\rightarrow p. 55 ff.), from the development of children (\rightarrow p. 66 ff.), and from the evidence of the past that we seem to have inherited from our ancestors special social skills:

- skills for social perception, the imitation of our fellow humans, social learning, teaching, and the rapid internalization of social norms (\rightarrow p. 85);
- motivations for teaching and communicating information to others, sharing resources within the group, avoiding and resolving conflicts, and for collaborating towards common goals;
- social emotions such as empathy, envy, anger, guilt, shame, and the ability to suppress our emotional impulses;
- moral intuitions such as sense of fairness, compassion, and autonomy (\rightarrow p. 117);
- a prosocial temperament, and a need to be with others.



Of course, we also inherited the capacity for aggressive and behavior selfish from our ancestors. This is because these behaviors were useful in situations in which our ancestors were not sitting in the same boat with others situations where competition within or between groups became the dominant kind of social interaction.

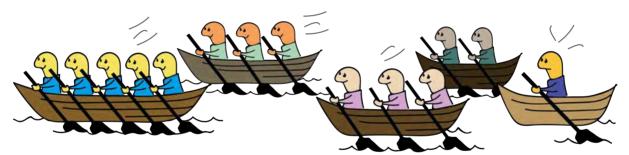




From Sociality to Ultrasociality

The evolution and history of our species is not only characterized by living in isolated and small hunter-gatherer groups, in which everyone knows each other and has personal contact. Our human traits have also been shaped by competition and cooperation between groups, and finally by fusion into ever larger groups.

When groups meet and compete with each other, e.g. because certain resources are limited, those who can unite into one entity and cooperate *within* the group will be at an advantage.



Competition between groups exists in many species. However, in our species this competition apparently lead to the fact that, within a relatively short time in evolutionary terms, we were able to "merge our boats" with those of other groups, into ever larger groups that "steered a boat together".

The fact that cooperation is beneficial in competition with others can be found in everyday proverbs and images of different cultures. "Together we are strong" - we humans seem to have an intuitive sense of it.



"Sticks in a bundle are unbreakable."

Kenyan proverb



This association into ever larger groups was made possible in our species by the ability for **language** and **symbolic thinking**. This ability allowed our ancestors to build a **common identity** and cooperate with others, even if they would never meet them in person.



So on the one hand, the history of humanity is characterized by conflict between groups, but on the other hand, in the long run this has resulted in the joining of groups of people into ever larger communities as we recognized and acted on our social interdependencies.

The fact that today many people of different backgrounds live and work together for global goals, universal human rights, and the well-being of humans and other creatures they will never encounter, is the result of this development.

However, due to the history of group competition, we also have a **tendency to quickly divide our social environment into groups - "Us" and "Them"** (\rightarrow p. 118). We automatically and relatively unconsciously recognize similarities and differences in our behavior, appearance, language, beliefs, and symbolic markings. Under certain conditions, especially when there is a sense that others are posing a "danger" or "threat", this perception may encourage aggression towards other groups.



Ancient Ancestors

"The capacity for symbolic thinking was the last great evolutionary innovation that made possible human ultrasociality. People now did not need to know personally another individual in order to determine whether to cooperate with him, or treat him as an enemy. (...) Symbolic demarcation of the group made possible cooperating with strangers who were clearly marked as "one of us." Symbols made it possible to identify with very large groups of "us," groups that included many more people than the small circle any individual person could meet and get to know personally. In other words, the evolution of symbolic thinking enabled defining as "us" a group of any size."

"Large nations of tens of millions of people did not, of course, arise in one fell swoop. The process was gradual and happened in stages. Several villages, threatened by a powerful enemy, could unite in a tribe and invent symbolic ways to mark and emphasize their union. In the next stage, several tribes could unite in a region-sized society; then regional societies into nations, and those, finally into supranational unions, such as large empires and whole civilizations. At each step, new symbols are invented to demarcate ethnic boundaries, or old symbols are stretched to encompass the larger society."

"As a new level of social complexity arose, the lower levels of organization were not completely eroded. As a result, people in general have coexisting identities, nested within each other. They can feel attachment and loyalty to their native town, their region, their country, and even to supranational organizations. The degree of identification with, and loyalty felt toward, an identity at any particular level can vary a lot."

Turchin (2006)

"The coevolution of tribal minds and tribal cultures didn't just prepare us for war; it also prepared us for far more peaceful coexistence within our groups, and, in modern times, for cooperation on a vast scale as well."

Haidt (2012)



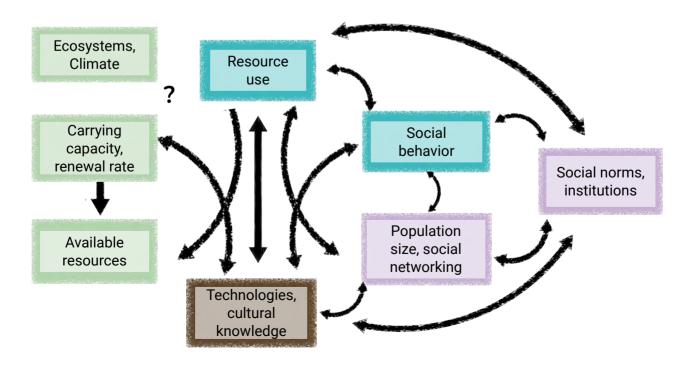
Ancient Ancestors

Cultural evolution of technologies and institutions



The evolved social and cognitive capabilities of our species enabled **cultural** evolution (\rightarrow p. 11 ff.): the cultures of the world adapted to their respective environmental and social conditions by developing their own **technologies**, knowledge, traditions, and norms. Technologies and cultural knowledge enabled our species to populate virtually all the world's ecosystems. Institutions and norms evolved to govern life in ever larger groups. However, over the long term, some norms and institutions may work better than others to manage the use and equitable distribution of shared resources, to distribute power, and to resolve conflicts within and between groups efficiently and effectively.

Increased **networking between people** accelerated cultural evolution - new technologies, new knowledge, and new ways to more efficiently extract natural resources. Often, this was accompanied by a further **increase in our population size**. But **the more efficient the technologies** became in exploiting natural resources, and the more people benefited from them, the more powerful were the **consequences of human behavior** on our social and natural environment.





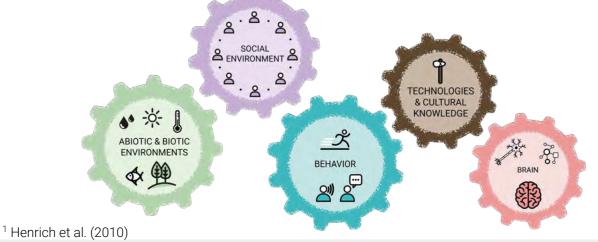
Cultural Diversity

For a long time, behavioral scientists and psychologists thought that we could learn about the behaviors of our species by just studying any humans and then generalizing findings to all the rest of humanity. For example, they thought that if we study the way that US-American college students think and behave, then we would know how all "normal" humans *should* think and behave.

In the 21st century, psychologists joined ethnologists and anthropologists and realized that human thinking and behavior is much more diverse and much more shaped by culture than was assumed¹, and so scientists started to carry out more **cross-cultural research**.

Through cross-cultural research, we realize how flexible the human mind is, and that we humans organize our communities in many diverse ways through norms, traditions, beliefs, language, technologies. Our **culture** and the **language** we speak **influences** everything from how we **perceive colors**, **space**, **time**, **our social environment** and our place in it, how we interact with family and strangers, how we **teach and learn**, the kinds of **personalities** that we might develop, the kinds of **things we value**, and our **judgment** of right and wrong. **Historic factors** like how our ancestors made a living, their experience of conflict, trade, religion, or epidemics still influence our cultural minds today.

However, through cross-cultural research we can also identify what all humans have in common, no matter their cultural background, and hence what it means to be human.







Egalitarianism in hunter-gatherers

One kind of culture that evolutionary anthropologists are interested in are small-scale foraging societies. This is because scientists think that many of them live similarly to how our species lived over the last 2 million years of our evolutionary history, and they can give us a glimpse about the ways of life of our ancestors.

Small-scale foraging societies live in groups of 100-200 people and make their living mostly from hunting and gathering wild animals and plants. They are often characterized by an **egalitarian social organization** (egalitarian or equal, comes from the french *égal*, and latin *aequalitas*) in which there is no social hierarchy and no dominance by one or a few individuals. Valuable resources such as meat are shared amongst everyone in the group. Hunter-gatherers also value **autonomy**, and they do not like to be told by others what to do.

This does not mean that there are no conflicts or attempts by individuals to dominate the group or to seize more resources! Rather, there are **conflict resolution mechanisms** that ensure that such attempts by "bullies" are unsuccessful and do not harm the group. For example, disruptive behavior is discouraged through appropriate reactions from the rest of the group such as shaming and public denunciations, and conflicts are resolved through negotiations. More severe violations can result in harsher punishments or even exclusion from the group. In this way, dominant or selfish actions of individuals are suppressed or marginalized through group collaboration.



A hunter of the Mbendjele in the Congo divides up meat portions for all the households of the group.



Cultural diversity of social organization

With the advent of **agriculture** starting about 10 000 years ago, our social organization began to drastically shift from these hunter-gatherer origins. Agriculture contributed significantly to an **increase in group sizes**. In addition, food could or had to be stocked increasingly, and domesticated animals had to be cared for. All of this had an impact on the social organization of our species: a shift to **sedentary lifestyles**, **wealth accumulation**, the **formation of hierarchies** in human groups, increasing **division of labor**, the ability to steal accumulated supplies and possessions from others, and the need to protect accumulated possessions from others.

How can life in such groups be regulated? It seems that with the increase in group sizes, the leveling mechanisms that worked well in small hunter-gatherer groups no longer worked sufficiently in such larger groups, and with increasing group size came an increasing **inequality in power and wealth**.

Throughout history and today, there have been **many ways that these large human groups have organized themselves** - in chiefdoms, kingdoms, or dictatorships with a strong social hierarchy and concentration of power; in democracies with the aim to prevent such unequal distribution and abuse of power; in socialist ways with the aim to distribute resources as equally as possible among all; or more capitalist ways with an emphasis on private property and resource distribution according to merit.

These different ways of living together also shape our social behaviors. People grow up and learn the **social norms** of their social environment - the behaviors that are typical and considered "normal" for members of a social group. As we grow up, we start to behave automatically according to these learned norms without thinking much about it, and we might get irritated or angry when we notice that other people do not behave in this way. Whether it is saying "hello" and "thank you", shaking hands, sharing with strangers, or littering, people across cultures might have different ideas about what is normal or not.



Cultural diversity of norms around fairness



Even though a sense of fairness seems to be part of our evolutionary heritage (\rightarrow p. 116 ff.) and has shaped the way of life of our ancestors and hunter-gatherers (\rightarrow p. 84), people across cultures can differ in how and in what situations their sense of fairness is expressed.

For example, sometimes fairness is the idea that everyone should get the same. Other times, fairness is the idea that those who contributed or achieved more, should also get more. Other times again, people might consider it fair if those who need more, also get more.

Researchers engage children and adults of different cultures in experiments to explore how they prefer to share things - how do they take different achievements, needs, or bad luck, into account? For example, in one experiment¹, children from a hunter-gatherer group tended to share such that everyone got about the same no matter their achievements, while children from Germany liked to distribute rewards according to who has achieved more. It seems that different ideas of fairness develop in cultures because of how and with whom people tend to interact and share resources in everyday life.



An experiment in which children played a game to earn candy, and then had to divide the pieces of candy between themselves.

How can we use our understanding about the cultural diversity and flexibility of our sense of fairness to create a more fair society, taking into account everyone's circumstances, their needs, good intentions, and contributions?

¹ Schäfer et al. (2015), see also Hanisch et al. (2021)



Cultural diversity of teaching and learning

Another set of human traits that we find across cultures is our ability and motivation to learn from and teach others (\rightarrow p. 69 ff.). However, the specific ways of how we learn and teach have been changing dramatically in recent centuries, and is highly diverse across schools today.

In hunter-gatherer societies, and through most of our evolutionary history, children do not learn in formal schools, but by playing freely with other younger and older children. Adults provide them with the tools of their culture to freely explore, but they hardly teach explicitly and don't judge their children's learning. In contrast, in most schools today, teaching and learning looks very different from this playful learning and exploring, yet there is also a wide diversity of norms about what teaching and learning should look like.

Cultural diversity is everywhere

We don't have to travel around the world to explore cultural diversity - just as there is cultural diversity between countries and ethnicities of the world, there is cultural diversity within countries and cities, between families, work places, schools, and groups of friends. What is considered normal in one family, school, or workplace might be considered strange and unacceptable in another.

How can we use our understanding about the immense cultural diversity in our species, and about the immense flexibility of our minds, to orient the cultures of the groups and communities we belong to towards greater well-being and sustainable development? For example, how can we use our understanding about the strong role of social norms in shaping our behavior, to create new norms, new ways of interacting with each other? How can we use our understanding about the diverse ideas of fairness to create a more fair society? How can we use our understanding about the diverse ideas the diversity of ways that humans teach and learn across history and across the world, to shape today's schools and education systems towards effective and engaging learning experiences?



Games offer further helpful analogies for thinking about how certain situations affect relationships and interactions between people (\rightarrow cf. p. 8).

In some games you only play "against yourself": You're sitting in your own boat, and it doesn't really matter how good others are in the game. You want to beat your own record, solve a tricky puzzle, be better than last time, reach the next level, or reach your goal.



 Some games are a "team sport": all players of the team are in the same boat. "My victory" is "our victory". Teams compete against other teams. The team that can work together better will have the long-term advantage. Competition within the team can jeopardize cooperation and be detrimental to the whole team.



In other games everyone plays against everyone: Everyone is sitting in their own boat and rowing, running, swimming, thinking, battling, learning against each other. "My profit" is "your loss"; "my victory" is "your defeat". The strongest, fastest, smartest, or the one with the best strategy wins.



It is not hard to predict how players should interact with each other in these different game variants - when and with whom they should cooperate and with whom they should compete. **However, it is not so clear in other games**.

Game network graphics based on Peoples et al. (2017)



Cooperation Games

Even in life, we all play a kind of "game" - because we live in social groups, we sometimes belong to different "teams", sometimes see each other as competitors, or sometimes play "against ourselves". There are different things to "win" or "lose": health, a long life, relationships, friends, enemies, family, money, success, reputation, or happiness. But in life, it is often not very clearly defined what kind of game we are in - whether, for example, everyone is in the same boat and should cooperate, or whether everyone is playing against each other. In such situations, it depends more on how people themselves perceive the situation, how they assess and react to the behavior of others, and the cultures and norms they create. In this way, the rules of the game often arise from the behavior of the players in the course of the game!

Game theory is an important method of behavioral research, with the aim of investigating the causes and manifestations of human social behavior in such situations. As with other games, scientists come up with situations that best reflect specific aspects of the situations and challenges of real life in social groups.

How will humans behave in these situations? Will everyone behave as if it's a team sport or will they see themselves as competitors? What do they actually want to win? Are humans interested in money, reputation, a good feeling, or a fair game? How are the behaviors of people of different ages and socio-economic or cultural backgrounds similar and different? Game theory experiments provide insights into the evolutionary, historic, developmental, and immediate causes and consequences of human social behavior.

The research questions and methods of game theory also help students and teachers to reflect on human behavior in everyday situations, and to **critically transfer insights** from such experiments to real-world challenges in communities ($\rightarrow p \ 155 \ f.$).



Do people voluntarily share with strangers?



In two standard games in game theory, **the Dictator game** and **the Ultimatum game**, people receive a certain amount of money (or some other attractive resource) - would they give away some of that unexpected win to a stranger? What kind of behavior do we expect from people in such a situation? Will they want to keep everything to themselves, or will they be willing to hand over a part to the stranger? Why, or why not? How will young children behave? Will all people, regardless of their background, behave in a similar way? Why, or why not? Will other primates behave similarly? Why, or why not? What happens if the partner can refuse the offered sum, and in this case both leave empty-handed? How can we transfer the conditions and observed behaviors in this game to real life?

Results from these experiments let us reflect on the causes and facets of human altruism and our sense of fairness, as well as the role of social emotions and social norms in our behavior.





Do people voluntarily contribute to maintaining a common resource?



Another standard experiment in game theory, the **Public Goods Game**, reflects the challenges that arise when a group of people has to maintain a common resource (\rightarrow p. 7). In such a situation, everyone is in the same boat, but selfish behavior can be beneficial to the individual.

For the maintenance of common resources, it is best that everyone fully contributes. For the individual, however, it pays to contribute less than others. But if nobody contributes, everyone in the group loses out.

How will people behave in such a situation, particularly if their behavior is not visible to others in the group? Will all people, regardless of their origin, behave in a similar way? Why, or why not? What role do **emotions**, **beliefs**, **or values** play in their behavior? What happens if we change the rules and conditions of the game? How do **anonymity** or **communication** influence the outcomes? **What rules and conditions of the game motivate people to act for the common good?** What rules and conditions of the game prevent people from acting for the common good?

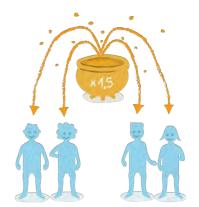
How can we transfer the rules and conditions and human behaviors observed in different versions of the Public Goods Game to concrete problems of sustainable development?



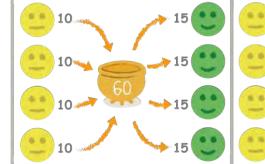
Cooperation Games



In the Public Goods Game, each member of a group receives a sum of money. Each one can deposit some of their money in a common "pool" or bank.



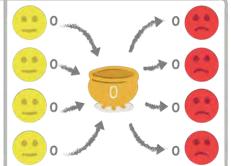
The total amount in the common pool is increased (e.g. by 50 %) and is then paid out equally to all members, no matter how much each one has deposited.



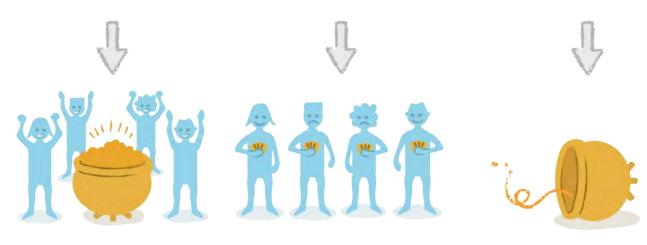
For all players, it is best if everyone contributes their entire sum, because then everyone gets paid out the most.



For the individual, however, it pays to pay less than others or nothing at all. They will gain more at the other players' expense.



But if everyone pays very little or nothing, everyone gets very little or nothing from the common pool.





Homo oeconomicus, or Homo sapiens?

Scientists used to think that the kind of game that humans generally play in real life is a competitive game - humans are interested in gaining the maximum material benefit for themselves in social interactions, and make rational calculations to achieve this. In economics, this model of human behavior has become known as *Homo economicus*. It has influenced the way many people think about humans and the way we organize our modern societies. We tend to think that in order to motivate humans to behave in certain ways, we just need to create enough material incentives, e.g. through discounts, bonuses, penalties, taxes.

However, through behavioral science experiments and observations, we know today that his model does not describe human behavior very well.

Humans across cultures seem to be motivated by much more than just material incentives, and they often do not act as "selfishly" as had been assumed. Humans seem to care about having a good conscience, their **reputation**, **prosocial values**, and respecting **social norms** (\rightarrow p. 78, 85). Even the meaning of the terms "selfishness" and "altruism" had to be rethought (e.g. is it selfish when someone helps another person because it feels good?).

Humans also often do not act as "rationally" as had been assumed. People often act intuitively (\rightarrow p. 110 ff., 115 ff), guided by (social) emotions, intuitions, and internalized social norms. Even the meaning of the term "rationality" had to be rethought (e.g. is it irrational if someone acts by a gut feeling or in a way that seems costly in the short-term, when the consequence of the action nonetheless contributes to the person's long-term well-being?).

In fact, material incentives can "backfire" or become a "self-fulfilling prophecy". People can become *Homo economicus* if they feel that their social preferences, values, and social norms do not matter or if they sense that other people are also self-interested material maximizers.







Most of these findings from behavioral science are actually familiar to us from our own everyday experience - we all know that we are often guided by our intuitions, we know what it feels like to "do the right thing" or to break the rules, and what it feels like when we observe someone else breaking the rules.

The question is: what can we do with these understandings about the causes of human behavior? Can we use them to promote the achievement of societal goals for human well-being and sustainable development?

For example, **nudging**¹ is a method to influence people's behavior that builds on our new understanding of human behavior. It does not use "carrots and sticks" like economic incentives, prohibitions, or coercion, but rather, it slightly changes environmental conditions and messages to appeal to people's intuitions. Importantly, the goal of behavioral change should be in the long-term interest of the affected individuals and/or in the interest of wider society. Thus, e.g. cigarette advertising is not a nudge (because the intended behavior is mainly in the interest of the cigarette manufacturer), while warnings on cigarette packets are nudges (because the desired behavior is in the long-term interest of the affected individual and society).

Experiments that use nudges in the lab and in the real world let us explore and reflect on the **ethics and effectiveness** of this method for fostering cooperation, sustainable development, and human well-being: Is the method of nudging ethically questionable because the behavior of people is deliberately manipulated, or is it harmless or even desirable because the aim is to steer people without coercion towards prosocial or other positive behaviors? Can and should - we use the method of nudging in our own lives, in our school or community to encourage certain behaviors in ourselves and others? If not, what are some other ways to motivate or enable humans to behave in certain ways? What role might values clarification or the development of competencies play?

¹ Thaler & Sunstein (2008); Schubert (2016)



Governing the Commons

Can we also learn from small and large communities around the world about how to sustain shared natural and social resources? After all, people live in communities which depend on their resources, and many have done so for millennia. Some communities have existed for many generations and still to so today, others have perished, while some have migrated or changed their livelihoods. How have different communities of people managed to survive for generations and to sustain their shared natural and social resources?

Political scientist Elinor Ostrom and her colleagues have been studying a variety of common pool resources in the world since the 1990s, such as fishing areas, grazing lands, irrigation systems, and forests. She wanted to find out to what degree communities in the world are experiencing a "Tragedy of the Commons" (\rightarrow p. 7) or are able to sustainably manage their shared resources.

She found that communities can be quite capable of sustainable resource management, but not always. Certain factors and conditions of the resource and social environment, norms and institutions, and behaviors of the user community seem to have a strong impact on communities' ability to manage their resources sustainably.

"Why should we teach the theory of collective action (...)? [T]he theory of collective action is a core explanatory theory related to almost every "political problem" addressed by citizens, elected officials, political action groups, courts, legislatures, and families. (...). Future citizens must understand the multiple threats that exist to any group of individuals who wish to accomplish a joint objective. They must know how to face the tragedies of the commons (...). Otherwise they are not prepared to face the problems they will encounter in the normal exigencies of everyday life. (...) [W]e have an obligation to provide students with effective theory about (1) how individuals overcome the many facets of social dilemmas that pervade all aspects of public life, (2) how to avoid the tragedy of the commons, and (3) how to learn how to take advantages of the opportunities that arise from conflict to better understand problems and use one's imagination to achieve conflict resolution."

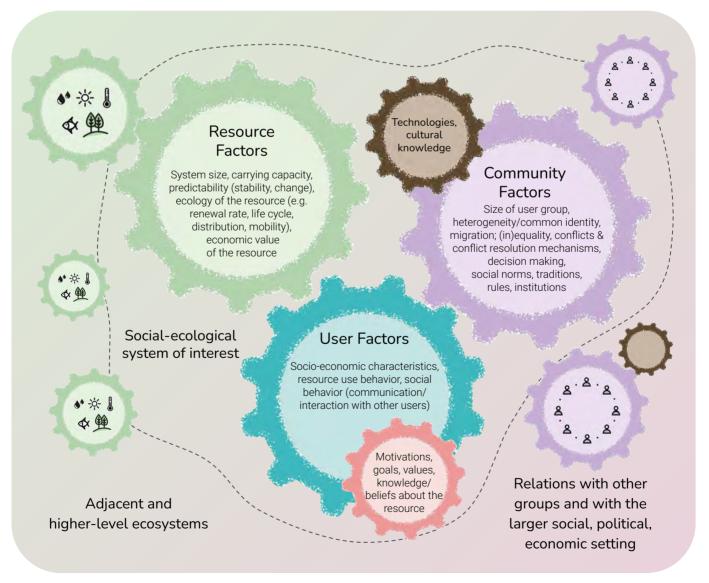
Ostrom (1998)



Governing the Commons



Elinor Ostrom's framework for analyzing social-ecological systems integrates a variety of factors that can influence how easy or difficult it is for a community to cooperate around sustainable resource management. We can explore how these factors interact and affect a social-ecological system through real-world case studies of common pool resources, as well as through computer models (\rightarrow p. 99 ff.), games, and experiments (\rightarrow p. 88 ff.) that model specific dynamics in common-pool resource situations.



Source: Hanisch et al. (2023) adapted from Ostrom (2009)



Governing the Commons

Elinor Ostrom and other scientists have also identified a set of **design principles** for successful cooperation¹, which we can use to analyze and foster cooperation in many groups.



Within Group Cooperation	0 Shared understanding The community works towards establishing a common ground of mental models relevant to communicating about problems, goals, and solutions.
	1 Clear group identity and shared goals It is clear who belongs to a group, and all members have a shared sense of identity and common goals.
	2 Fair distribution of costs and benefits The costs incurred by members for cooperation are distributed in proportion to their benefits from the cooperation.
	3 Fair and inclusive decision-making Most individuals in the group can participate in decisions that affect them, set or change the rules of the game.
	4 Transparency and monitoring progress towards goals The community observes and monitors whether everyone behaves according to the rules, and to what degree common goals are achieved.
	5 Appropriate feedback to helpful and unhelpful behavior Rewards for valued behaviors <i>and</i> punishments for misbehaviors start at a low level (e.g. friendly discussion), and are increased in proportion to how helpful or unhelpful the behavior is.
	6 Fast and fair conflict resolution The group has mechanisms for resolving of conflicts among members in ways that are fast (efficient) and perceived as fair by those involved.
Between Group Cooperation	7 Recognition of group autonomy The group has a minimum of rights and the freedom to set its own rules and to implement principles 0-6 in ways that work for them.
	8 Appropriate relations with other groups Groups exist on many nested levels, with appropriate relations between levels of organization. Principles 0-7 apply to every scale of human social organization.



Computer Models

Evolution, behavior, and **sustainability** are associated with multiple **learning difficulties** because they are the result of complex interactions within and between organisms and their environment.

To study complex phenomena like human behavior, evolution, and socio-ecological systems, scientists use **models**. Models simplify, distort, magnify, or eliminate certain aspects of reality in order to study and understand a particular phenomenon. Behavioral experiments, other species, analogies, and games are kinds of models used by behavioral scientists. Scientists also increasingly use **computer models**. Computer modules can be more precise and more complex than experiments and games and allow scientists to study phenomena under many different conditions.

"All models are stupid. And we need more of them." Paul Smaldino (2017) "All models are wrong, but some are useful." George Box

Agent-based models

Many evolutionary and behavioral scientists use **agent-based models**. These models simulate the behaviors and interactions of agents in an environment. **Agents** are simple entities that have behavior and can represent entities such as molecules, cells, organisms, and groups of organisms. Agents often have simple behaviors, e.g. they may perceive and react to conditions, move, cooperate or compete with other agents, reproduce, and so on. These simple agent behaviors and interactions produce outcomes at the level of the whole system that cannot be entirely predicted nor reduced to the behavior of individual agents. Such models are therefore well suited for developing **systems thinking** in learners, and for observing, investigating, and understanding social interactions and evolutionary processes in social-ecological systems. Just like telescopes and microscopes, they allow us to recognize phenomena that may be otherwise invisible to the naked eye¹.

¹ Goldstone & Wilensky (2008)

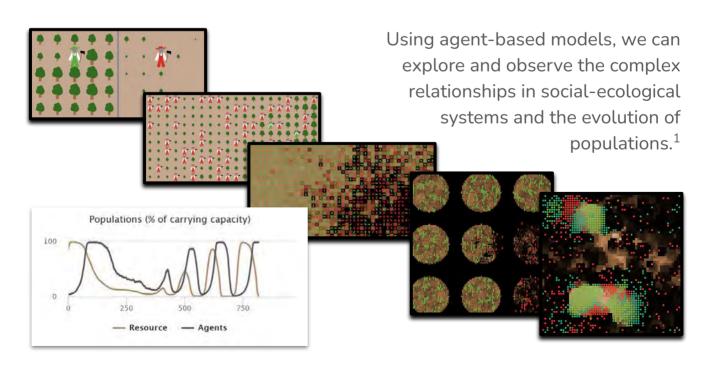


Computer Models

An alternative to agent-based computer models are mathematical - or equation-based - models. They involve mathematical equations and graphs of population-level variables. Examples that students might learn about are the logistic growth function or the Lotka-Volterra predator-prey model. These equations can be quite difficult to understand, and they are a very abstract representation of populations and systems. Agent-based models, on the other hand, are easier to understand intuitively, can better represent and model population structures, and allow us to visualize and observe the development of populations of agents.

"Students can reason about and visualize individual animals in an ecology far better than they can population levels. They can draw on their own body and sensory experience to assess and/or design sensible rules for the behavior of individuals. They can therefore make much greater sense and meaning from the agent-based representations."

Wilensky & Papert (2010)



¹ We develop agent-based computer simulations with the software NetLogo (Wilensky, 1999).





Agent-based computer models can help us **understand why maintaining shared resources can be challenging** (\rightarrow p. 7). In agent-based models, we can observe that competition among individual agents sooner or later can endanger the maintenance of a common resource, and thus the entire agent population.

Because of this competition for resources, those that use more of the resource than others, or that can use the resource more efficiently than others, have a selective advantage. Their behaviors will spread in the population - for example, by producing more offspring or because more individuals copy their behavior. However, when the entire population finally behaves this way - does this not lead to the depletion of the entire resource? And will this population not ultimately die out, or at least be plagued by a constant cycle of collapse?

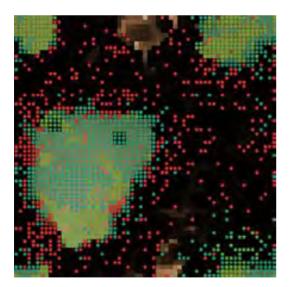


Thus, the **tragedy of the commons** (\rightarrow p. 7) is also an important concept in evolutionary biology. Evolutionary biologists examine the question of how different species and populations prevent a tragedy of the commons. Researchers are also investigating this question with the aid of agent-based computer models. How can we change the conditions and behaviors of elements in a model so that a population is not endangered by competition and resource overuse? And do we find similar conditions and behaviors in real-world populations?



Agent-based simulations can also help us understand why social behavior or other **mechanisms that limit competition and conflict** within a population are **central to the sustainable development of a community**.

The degree to which everyone is in the same boat (\rightarrow p. 8 f.), is the degree to which cooperative social behavior will benefit everyone - even if it can lead to individual disadvantages in the short term. This view helps us explain why organisms such as bees (\rightarrow p. 56 ff.) have evolved sophisticated behaviors that allow them to persist as a community. Moreover, this view helps us explain why we as humans also show behaviors that allow us to sustain cooperation in communities over long periods of time (\rightarrow p. 61, 78, 80, 84, 93). Furthermore, this view also helps us explain why communities in the world have developed certain norms and institutions that help govern their coexistence (\rightarrow p. 97).

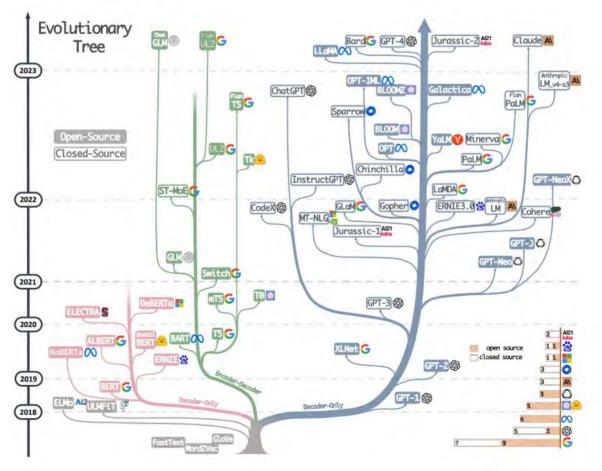


Agent-based computer models can help to understand the functions of these behaviors and mechanisms for cooperation and sustainable resource use in a community. By drawing connections between the models and other content anchors in our design concept, students can **critically transfer** this understanding to various sustainability dilemmas: past, present, and future.



Cultural evolution of machine behavior

As products of cultural evolution and entities that have behavior, scientists are using the tools and concepts of evolutionary and behavioral science to explore the evolutionary history, development, and functioning of computer models, especially Large Language Models (LLMs) like GPT¹. As of 2023, more than 16000 such models have been created², many being derivatives or "offspring" of earlier models. It is unclear where this development will lead and how it will impact our world. This is why it is critical to study the continued cultural evolution and diversity of these new "species" so that we can influence their evolution towards valued directions.



An evolutionary tree of Large Language Models. Image source: Yang et al. (2023)

¹ Brinckmann et al. (2023); Rahwan et al. (2019) ² Gao & Gao (2023)



Human-Machine Coevolution

Humans have been coevolving with tools for millions of years. How will modern technologies like Artificial Intelligences (AI) impact and interact with human cultural evolution? We can analyze this question by looking at how AI might impact evolutionary processes (\rightarrow p. 13) and outcomes¹. Reflecting on these possible impacts helps us to create machines and interact with them in ways that leads to valued outcomes.

	Capabilities of machines and influence on cultural evolution
How might machines impact the variation in cultural traits?	 Access to broader knowledge base than any human can have; exposure of humans to more diverse ideas Ability for novel recombinations of ideas Potential displacement of human role in creativity and innovation
How might machines impact the selection of cultural traits?	 Algorithms expose humans to certain kinds of information and impact who humans are connected to and learn from Interaction with human feedback can lead to undesirable outcomes such as spread of misinformation Specialization of humans and machines for certain tasks
How might machines impact the transmission of cultural traits?	 Preservation and accessibility of vast amounts of diverse human knowledge Fast processing and dissemination of new information Danger of reinforcing human biases (→ p. 113) Unequal access to technologies and hence to information Danger of erosion of cultural diversity



Computer Models

Machine learning and human learning

Scientists are using AIs like Large Language Models as a model for human learning, and are also using these same models as a new conceptual tool to reinvestigate what we know and don't know about human learning. Are AIs really "intelligent", are they "conscious", do they really "understand", what do "intelligent" or "conscious" or "understanding" even "really" mean as concepts?

Cognitive and computer scientists are starting to work together to explore these comparisons. Currently, the comparison might look like the table below¹, but machines are continuously evolving at a rapid pace and there are many open questions.

	Human Learning	Large Language Models
Similarities	larities Pattern recognition in language data; statistical learning ab probabilities and associations of events; role of feedback by ot agents (reinforcement learning)	
Differences	Input from many senses	Only text input
	Role of embodied cognition, emotions/moral intuitions, episodic memory in meaning making	No body, no emotions, no morals, no episodic memory
	Long evolutionary history of human brains	Model training only "from scratch" with raw text data
	Role of deliberate reasoning, logic, mental simulations	Unclear
Open questions, uncertainties	Can AIs generalize and transfer concepts the way humans do? What does it mean for humans or AIs to understand?	

¹ informed by Binz & Schulz (2023); Frank (2023a,b); Shiffrin & Mitchell (2023)



Our Mind

We can easily compare a human characteristic such as upright walking with that of other species - the similarities and differences are clearly visible in terms of behavioral and physical features.





However, our human "inner behaviors" (\rightarrow p. 14 f.) are more difficult to compare with those of other species. At the same time, these are the questions that often fascinate us the most, especially when we observe our closest relatives and wonder - What are they thinking? Do they even "think"? Actually, what is "thinking"? What do they feel, and why? What is important to them in life? Are they worried about the future, do they have hopes, are they making plans? Do they communicate to each other about their experiences, ideas, hopes, and feelings?

We humans, through our language, can communicate and tell each other about our "inner behavior" - such as our thoughts and feelings. But how can we find out if other species have thoughts, ideas, or feelings similar to ours?





Our Mind

We can start simply by **observing and "exploring" our own minds**: what different things does it actually do? Scientists have come up with various **metaphors and analogies** to describe the different behaviors in our mind. For example:

- Brain as an ecosystem our "self" is not one thing, but consists of many things; the brain is a like an ecosystem with populations of neurons and neural networks cooperating and competing for limited resources.
- Learning as evolving our mind the way we learn new behaviors throughout our lifetime is similar to the evolution of species through generations.
- Emotions as characters inside us we have different ways of perceiving, thinking, and communicating depending on which emotions take center stage.
- "Fast Thinking", "Slow Thinking" some of our mental processes are more like automatically occurring intuitions, other mental processes happen more through conscious concentration.
- "Moral taste buds" we have moral intuitions that, similar to our taste buds, can lead us to quickly judge between "sweet" or "disgusting", "good" or "bad", "just" or "unjust", "right" or "wrong", "us" or "them".
- "Mental time travel" we can "travel through space and time" in our minds while our bodies and senses remain in the here-and-now.
- The "noticer", the "discoverer" and the "advisor" the "noticer" is our ability for mindfulness; with the help of the "discoverer" we try out new things and learn by trial-and-error; using the "advisor", our inner voice, we can try things out "in our heads" instead of in the world and learn from our experiences.

Why does our mind do these different things? Which of these different things do we have in common with other animals, and which not? With which do we come into the world, and which ones develop in the course of our lives?

Scientists are studying and comparing the behaviors of other species, of developing children, and of people from different cultures, in order to understand the causes and functions of these different processes. These insights can also help us understand our own inner experiences, and to relate to them in a more accepting and flexible way.





Brain as an ecosystem - and the idea of a decentralized self

Some cognitive scientists use the metaphor of the brain as an ecosystem of many cells and networks, competing for limited resources like energy and attention, and cooperating to form neural tribes.

"If a neuron is friends with another neuron, it excites that other neuron. If a neuron is enemies with another neuron, it inhibits that other neuron. These two simple mechanisms—excitation and inhibition—allow for amity and animus, respectively, in the neural jungle"

"Many aspects of experience, or possibly all aspects of experience, reflect the goings-on of multiple brain regions acting as a population."

"To whom do these voices belong? To you, of course, yet they seem to come from different individuals within you—a brave you, a cautious you, a you who triumphs, a you who trembles. It's hard to tell which you is the real one. The chorus of voices makes you feel like you're not one person but many. The truth is, you are many. You are a population."

"Can you decide anything if you're not one person? The answer is that you can, because populations do so all the time."

Rosenbaum (2014)

Viewing ourselves as a collection of things, rather than one fixed thing, can be a helpful mental model: there is space for variation, flexibility, and change. Studies show that holding on to a fixed, monolithic concept of the self ("I am ...") is linked to a number of unhelpful behaviors¹. For these reasons, it can be helpful to develop a conception of the **decentralized self**. Many of the metaphors and models explored in this **Our Mind** section in fact serve to bring these different elements of our mind and experience into awareness - a necessary first step for the ability to observe and relate to them in new ways.

¹e.g. Bernstein et al. (2015); Dweck (2006); Schwartz & Sweezy (2019)



Our Mind

Learning as evolving our mind

Just like the brain can be seen as an ecosystem, so the process of learning can be seen like an evolutionary process (\rightarrow p. 12 f.), and evolution can be seen as a learning process. They are both processes of **adaptive change in populations** that can be understood through shared underlying concepts, only that they are happening on different time scales and through different mechanisms.



Learning is a process of change in knowledge, behaviors, and skills over developmental time, leading to adaptations of individuals to their environments. **ATERN**

Evolution is a **process of change** in the traits of populations and species over **generations and phylogeny**, leading to **adaptations of species** to their **environments**.

Which kinds of knowledge, skills, behaviors do you want to evolve? How might certain skills, attitudes, and competencies help us to evolve our mind?

Evolutionary processes	Skills, attitudes, and competencies
Variation-producing processes	Curiosity, openness to novelty and diversity, exploring new ideas and behaviors
Selective retention	Being aware of one's values and emotions, guiding our attention, engaging in behaviors that are in line with values, practice and persistence
Niche construction	Noticing and developing opportunities and environments for valued learning in ourselves and others; creating environments that reinforce valued behaviors



Emotions as characters inside us

What are emotions and feelings? How many emotions are there, and which ones do we have in common with other animals? Why do different emotions exist? Do all humans across cultures experience the same emotions, in the same way? How might words, culture, and emotions interact?

Exploring these questions can help us **notice and better understand our emotional experiences**, and relate to them in more helpful ways.

The Pixar Movie "Inside out" is a great metaphor that can help us develop a more helpful relationship with our emotional experiences. Related to a mindset of a decentralized self, it can help us observe our emotions and how they color our interpretations and thoughts, rather than only seeing the world filtered through our emotions.

"Inside Out was, I think, the most powerful revision of how we think about emotion for 2000 years. From Plato to Kant, we have thought about emotions as disruptive dysfunctional irrational processes, and we should suppress them. And Inside Out comes along and says they are the very foundation of story and relationships and purpose in life."

"Inside Out has the most unlikely hero in the history of filmmaking — Sadness and this becomes an opportunity for our culture, which loves to suppress sadness, to medicate sadness, to not talk about it. And suddenly it opened up this conversation that sadness is okay, you move through it. It transforms human relationships. In some sense, Inside Out was this meditation on accepting and embracing negative emotions."

Keltner (2021)







Our Mind

Fast thinking, slow thinking¹



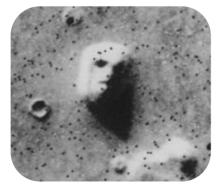
As we look more closely at our perception and thinking, we find that some of it is quite automatic and effortless. Other situations require our conscious concentration and can quickly make us tired. For example, calculating the solution for "2 + 2" feels to us quite differently than calculating " 17×23 ".

In psychology these different processes are sometimes roughly divided into two ways of thinking - a fast "System 1", and a slow "System 2". Often we think our System 2 is in control, when in fact System 1 dominates our perception, our thinking, and our actions. System 1 helps us to navigate and survive in a complex, dynamic world.

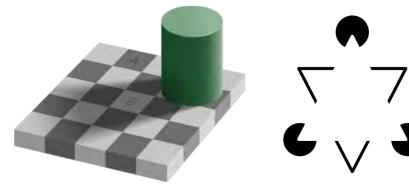


Optical illusions allow us to experience the work of our "System 1" and to reflect on its functions.

Why does our brain distort and simplify our perception of the world?



¹ sensu Kahneman (2011)





Why thinking fast?

We have many of the mental activities of "System 1" in common with other species of animals, and we are born with some of these abilities. Other intuitions also develop in the course of our life through repeated experience of stimuli and practice. That's why we can barely suppress reading words in our mother tongue or solving "2 + 2", even though there was a time when this was new and hard work for us.

The **function** of these unconscious and automatic intuitions, for us and other animals, is to quickly learn the regularities of our social and natural environment, to perceive them quickly and without much energy expenditure, and to respond to them rapidly. System 1 enables us to navigate and survive in a complex, dynamic world, but it does not always provide a factually accurate view. **Simplified or distorted perceptions of the world** have become part of how humans think because they may not have any negative effects, and instead often positive effects for us.

Thus, it is very difficult for us to prevent us from seeing faces where there are none, or getting "tricked" by other optical illusions. All we can do is **learn when System 1 distorts and simplifies our perception of the world**, and not always blindly trust our perception.

"The capabilities of System 1 include innate skills that we share with other animals. We are born prepared to perceive the world around us, recognize objects, orient attention, avoid losses, and fear spiders. Other mental activities become fast and automatic through prolonged practice."

Kahneman (2011)



Why thinking slow?

The mental processes of System 1 and System 2 are not strictly separable many processes are more or less automatic, more or less conscious, more or less flexible depending on many factors. Moreover, other species, e.g. primates, may have certain "slow thinking" skills. Nevertheless, the activities of System 2 seem to be **particularly pronounced in us humans**. They probably originated throughout our evolutionary history because certain mental abilities, such as controlling emotional impulses in social situations, focusing on activities such as learning and teaching, the use and manufacture of complex tools, and coordinating body movements, had become increasingly important to the survival of our ancestors. System 2 is related to the activity of the cerebral cortex and we do not come into the world with it - it **develops throughout our lives**.

"The operations of System 2 are often associated with the subjective experience of agency, choice, and concentration. (...) When we think of ourselves, we identify with System 2, the conscious, reasoning self that has beliefs, makes choices, and decides what to think about and what to do."

Kahneman (2011)

We often think that our System 2 (our "self", our "intention", our "will") is in control; after all, we are mostly only *aware* of System 2. In fact, System 1 generally dominates our perception, our thinking and acting, in part because System 2 consumes a lot of energy and is exhausting! Take a moment to reflect on how often and in what situations you and your mind use System 1 and System 2 thinking over the course of a day.

How might an understanding of the roles and subjective experience of fast and slow thinking help students develop a **growth mindset**? How can we make use of our fast and slow thinking skills to become better at things we care about?



Cognitive biases

Many intuitions produced by System 1 are called **cognitive biases** - a tendency of our mind to perceive and interpret the world that is somewhat distorted from reality. Behavioral scientists have identified hundreds of such cognitive biases that distort our everyday perception and judgment. **How do such cognitive biases influence human behavior, well-being, and sustainable development?** In fact, while they may have important functions, they can also lead to negative consequences in how we interpret and react to the world around us.

Here are examples of a few common cognitive biases. Can you think of how they might be helpful, or might have been helpful for our ancestors, but also lead to negative outcomes to our own and others' well-being in today's world?

Cognitive bias	Functions?	Negative consequences?
Confirmation bias the tendency to notice information that confirms our own existing beliefs, and to ignore information that contradicts our own beliefs.		
Agency detection the tendency to notice and imagine agency around us, i.e. the presence, goals, and behaviors of organisms or other entities		
Negativity bias the tendency to notice and remember negative things more strongly than neutral or positive things (e.g. harmful events, negative interactions with others, unpleasant thoughts, sensations, and emotions)		
Ethnocentrism, In-group bias the tendency to think that one's own group and its beliefs, customs, and behaviors are better, morally superior, and normal, and that those of other groups are bad, immoral, or strange		



Agency detection

One kind of cognitive bias is our ability to detect the existence of diverse agents (e.g. humans and other organisms) and to ascribe certain **perceptions**, **beliefs**, **goals**, and **goal-directed behaviors** to them. This helps us, and many other animals, be aware of, predict, and react to other creatures in our environment. Humans seem to have a hyperactive mode of agency detection, which develops very early in development. As a result, we **tend to explain many phenomena by appealing to the goals and behaviors of agents**, even to things that are not alive like machines, and to more abstract entities like societies, nations, and organizations. Specific cultures create social norms and shared beliefs about the proper attribution of agency vs. other causes across specific contexts.

However, our tendencies to explain phenomena primarily through the actions of (a few) agents can be harmful to ourselves or others. For example, **we may not see the complex causes** involved in phenomena like social (in)equality, climate change, corruption, mental health, or cultural change (as is often the case in conspiracy theories), and may therefore not be able to see and evaluate certain solutions. This is why developing **systems thinking** in such a way that agency and other causes can be integrated, is an important learning goal in sustainability education.





¹ Haidt (2003)

Our Mind

Emotions and Fast thinking influence our moral judgements

A basic insight of social psychology is that our **beliefs about ethical-moral issues** are also largely **influenced by "fast thinking" and (moral) emotions** like guilt, contempt, anger, gratitude, and compassion¹. People tend to quickly decide what is morally "right" and "wrong" through intuition and emotion, and only then, through conscious, rationalizing thinking, find reasons that support their initial intuitions.

This fact alone does not mean that this is a bad thing! Because without this emotional component, people would hardly care to commit themselves to different purposes, to take to the streets, and to address perceived problems in society together with like-minded people.

However, intuitions give us a sense of certainty, truth, and identity. We believe we know all the important facts about the matter, that we have come to our opinions through careful reasoning, and that we are therefore on the "right side". Critically, the people on the "other side" feel just the same!



Our Mind

"Moral Taste Buds"?

Social psychologist Jonathan Haidt compares these moral intuitions with our taste buds. This analogy may help us to understand the evolutionary origins and the individual development of moral intuitions, as well as the variation in "moral tastes" among humans, and find ways to relate to them more flexibly.



"We humans all have the same five taste receptors, but we don't all like the same foods. (...) Just knowing that everyone has sweetness receptors can't tell you why one person prefers Thai food to Mexican. (...) It's the same for moral judgments. To understand why people are so divided by moral issues, we can start with an exploration of our common evolutionary heritage, but we'll also have to examine the history of each culture and the childhood socialization of each individual within that culture."

Haidt (2012)

Just as all humans share the same taste buds because of our common evolutionary history, humans seem to also share a set of common moral intuitions because of our common evolutionary history. Our moral intuitions are **part of our evolutionary heritage** because they **had a significant function** in the group life of our ancestors. They helped them to notice conflicts in group living and to solve these together.



Our Mind

Here are some of the "moral taste buds"¹ that have a big impact on our opinions. They can be of various strength among people, be expressed in different situations, or in response to different stimuli.



ŝ

Care / Harm

Protect others from harm; feeling of compassion, empathy; aversion to violence, neglect



Fairness / Cheating

Others should have equal rights, duties, opportunities; aversion to cheaters, free riders



Freedom / Oppression

Aversion to oppression, restriction of freedom and liberty



Loyalty / Betrayal

Fidelity to one's own group, patriotism, sacrifice for one's own group; aversion to treachery, infidelity



Authority / Subversion

Respect for traditions, established institutions, legitimate authorities, leadership, order, stability; aversion to instability, change, disobedience



Purity & Sacredness / Disgust & Degradation

Attachment to what is considered "pure" and "sacred"; aversion to violations of social norms and contamination

¹ adapted from Grinberg et al. (2018), Haidt (2012)



Morality binds and blinds

Just as cultures of the world have developed their own regional cuisine, each community builds its own "moral cuisine" to please our moral taste buds, sometimes adding unique local "flavors" like "honor", "privacy", "honesty", "truth" or "property", shaped by (or even as an adaptation to) historical and socio-ecological circumstances ($\rightarrow p. 83, 86$).

Just as individuals have developed their own eating habits and food preferences, people also have different "moral tastes" due to their different individual experiences and influences from their socio-cultural environment.

Just as humans can develop a shared identity around common cultural cuisine, our intuitions about "right" and "wrong", "good" and "bad", "normal" and "unnormal" allow us to develop an identity with other people and work together for common goals (\rightarrow p. 78, 80).

At the same time, however, **these intuitions make us distinguish and separate** "**our**" **group from others**, with the consequence that we do not open ourselves to the important insights and experiences of others, and have difficulty working together toward common goals, even when we may actually be in the same boat.

"Morality binds and blinds. It binds us into ideological teams that fight each other as though the fate of the world depended on our side winning each battle. It blinds us to the fact that each team is composed of good people who have something important to say."

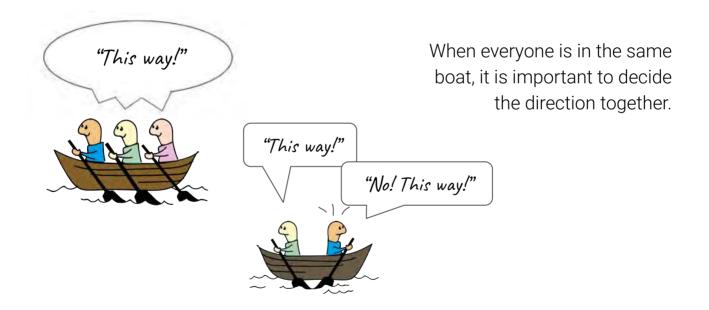
Haidt (2012)

Do you agree that each team is always composed of "good people"? How does an answer to this question influence the way we approach disagreements?



Thus, cognitive biases, moral intuitions, and group-thinking indicate that it **might be difficult for humans to critically evaluate their beliefs and other people's claims**, especially in today's complex world.

Because of these behaviors of our mind, humans often have a hard time coming to the same beliefs and conclusions through open exchange of experiences and opinions, unlike the efficiency of decision making in a bee colony (\rightarrow p. 56 ff.). However, such an open exchange of opinions with everyone in our group is the foundation of a functioning democracy and helps us to learn.



Thus, social problems (including sustainability challenges) often lead to disagreements between people about what is important, right, and true. Often people are divided into groups, and each group considers itself and its attitudes to be "good," "normal," and "justified". The others appear "abnormal", "bad", "dangerous", "ignorant", and "morally reprehensible".



Our Mind

Furthermore, our social mind has not evolved to identify objective truths but to believe what works for us in our physical and social contexts. In today's complex world, believing and spreading factually false things may not have immediate bad consequences for us, so there may not be any correcting feedback to our beliefs. In fact, believing and promoting such things may actually be adaptive and have positive consequences, like having a sense of certainty, identity, and belonging, or having many followers or viewers. Hence, our main motivation when arguing with others about issues can often be to win and persuade, rather than to come to a better understanding¹. Humans may also be prone to believe in conspiracy theories because detecting potentially harmful coalitions in our social environment was adaptive in the past.

"We propose that people possess a (...) mental system to detect conspiracies that in all likelihood has been shaped in an ancestral human environment in which hostile coalitions - that is, conspiracies that truly existed—were a frequent cause of misery, death, and reproductive loss."

van Prooijen & van Vugt (2018)

Most issues today are also so complex that no single human can have a complete understanding of the issue. We are forced to build our opinions and beliefs on what other people tell us, rather than on our own observations - a feature of the cumulative nature of human culture (\rightarrow p. 64 f.). Under these circumstances, the **question of which information sources we** *trust* become more and more important.

"Misinformation is less about information and more about trust. (...) Cultural evolution reveals that we learn what is right and true not through a deep causal understanding of information, but through trust in whom we receive the information. (...) Trust that the sources of information are knowledgeable, prestigious, sincere, and in the same cooperative group, such that actions are for our mutual benefit."

Schimmelpfennig & Muthukrishna (2023)

¹ Mercier & Sperber (2011)



Critical thinking and intellectual humility

Given these features of our evolved mind, the competency of critical thinking, and the related attitude of intellectual humility, are important learning goals, that are at the same time difficult to attain, especially across topics¹.

We think that **understanding our mind** and how it operates in today's complex world, **metacognitively noticing** and **reflecting** on these aspects of our mind, and practicing certain skills, can be helpful to foster these competencies.

After all, **intellectual humility** involves the awareness and acceptance that our mind tends to distort and simplify the world and that we hardly ever have enough knowledge to truly understand and be certain about a complex issue, as well as acknowledging other people's ideas and being open to them². Similarly, critical thinking has been said to be about overcoming cognitive biases³.

A great way to **practice critical thinking and intellectual humility** in the classroom are discussions. However, students need to be supported to lead discussions in a way that promotes mutual understanding, openness to new views, and a more constructive exchange of ideas. This can be achieved when discussions aren't framed as pro-contra debates with the goal of winning, but with the goal of mutual understanding - guiding students to be aware of and reflect on the many causes of their own and others' opinions, including the role of individual experiences, learned social norms, and moral intuitions.



Furthermore, evaluating critically the degree to which various people and groups show intellectual humility, have prosocial aims, and have norms in place to critically question and adapt their own beliefs, can help us decide which groups and information sources we might trust. **Media literacy** is therefore an increasingly important component of critical thinking.



"Mental time travel"¹

As we look more closely at our perception and thinking, we also find that we are quite often "somewhere else". We may be physically sitting in the classroom, walking down the street, or lying in bed, but in our minds we are wandering around in time and space: we remember a situation of yesterday or last year and replay it like a movie, we imagine ourselves in a situation tomorrow or in ten years, and wonder or worry about all sorts of situations that have nothing to do with our experience in the here-and-now.

Scientists call this mental behavior "mental time travel". Why do we have this behavior? Can other species do it too? Why or why not? How and when do we develop this behavior in the course of our lives? Tinbergen's questions (\rightarrow p. 140 ff.) can guide us in exploring the various causes of our mental time travel behavior.

Mental time travel

- Function: To use past experience in order to imagine different possible futures and act in the present towards selected future goals
- Mental time travel depends on parts of the brain evolved among many animals. Many animals probably have the ability to remember things, and some may have the ability to imagine the immediate future. However, in us humans this ability has been vastly elaborated.
- It develops in the course of our life. Children increasingly gain an idea of the past and the future, and integrate these ideas into their actions. Hence, none of us can remember or mentally travel to our first birthday. But if you are old enough to read this text, then mental time travel probably influences much of your everyday experience, sometimes in negative, and sometimes in positive ways. Through language and the transmission of cultural knowledge, including science, we gain an idea of an ever more distant past and future.
- Mental time travel can occur automatically (System 1), but can also be consciously controlled by us (System 2)

¹ sensu Suddendorf & Corballis (1997)



Our Mind

"What is in your pockets? Chances are you carry keys, money, cosmetics, a Swiss Army knife, or other tools—because they may be useful at some future point. Humans have the ubiquitous capacity to imagine, plan for, and shape the future (even if we do frequently get it wrong). This capacity must have long been of major importance to our survival (....) and may have been a prime mover in human cognitive evolution. Stone toolkits and spears from archaeological finds suggest that the ancestors of modern humans already prepared for the future hundreds of thousands of years ago. (...)

Of course, other animals also act in ways that increase their chances of future survival. Many species have evolved preparatory instincts that lead them, for example, to build nests or hoard food. [Learning] further allows individuals, rather than entire species, to predict recurrences on the basis of cues (for example, a smell signaling food). (...)

Great apes even seem capable of imagining situations they cannot directly perceive. They can also make simple tools to solve nearby problems, such as fashioning an appropriate stick to obtain food that would otherwise be out of reach. Yet there seems little evidence that animals ponder the more distant future."

Suddendorf (2006), p. 1006

"A good deal of human conversation consists of mutual time travels down memory lane. Shared memories are the glue for the enlarged and complex social nets that characterize our species and that go well beyond mere kinship."

Suddendorf & Corballis (1997)

Our capacity for mental time travel is still relevant today and is an important basis for developing the competency of **future thinking**. With this competency, we can more explicitly imagine and evaluate possible future scenarios and ways to get there, and orient our behaviors today towards preferred futures.



Our Mind

The "Noticer", the "Discoverer", and the "Advisor"



Other behavioral researchers¹ have developed the metaphors of the "Noticer," "Discoverer," and "Advisor" to distinguish different behaviors in our mind.

The Noticer

- Function: To detect physical, psychological, and environmental stimuli in the immediate here-and-now
- The noticer is evolutionarily very old, depending on how one defines "sensing" and "perception".
- We are born with the noticer, but it also develops over our lifetime, as we practice being able to notice more and more different things, for example through regular mindfulness exercises and having concepts for different kinds of experiences.
- The noticer is automatic (System 1), but can also be consciously controlled by us (System 2). For example, if we want, we can guide our attention and notice a sensation in our left foot, what is going on in our mind, or the sounds we hear. The noticer does not travel in space and time, it is always in the here-and-now.

Mindfulness

The noticer is our ability for mindfulness. Mindfulness has become a popular topic in education. But what exactly is mindfulness? And why might it be important and helpful for human well-being and sustainable development? People may have different **mental models about what mindfulness is**. For example, people might think that it is the same as meditation, that its purpose is to make us relax, to think and feel positively, or that it requires a lot of time, effort, and sitting in a quiet place. These ideas may not be so helpful and might prevent people from actually practicing their Noticer abilities. Mindfulness involves guiding our attention to the present moment and an openness and acceptance of current experience². This can be practiced even - and maybe especially - when we're in a rush or stressful situation. **Mindfulness can help us pause and more flexibly choose how we want to act and be in the world**.

¹ Hayes & Ciarrochi (2015), Ciarrochi & Hayes (2018) ² Hildebrandt et al. (2017)



Our Mind

The Discoverer

- Function: To increase our possibility for new behaviors and understandings through trial-and error learning
- The discoverer originated about 500 million years ago with increased behavioral flexibility of animals, and so we have it in common with many animals. Apes seem to have particularly active discoverers. Our discoverer may have been further elaborated in the last 50 000 years of human evolution. However, in us humans, our ability for language and symbolic thinking (→ p. 126) can both expand and constrain our discoverer.
- We are born with the discoverer. In childhood and youth, our discoverer is particularly active through play and willingness to take risks. Even in adulthood, we still like to play, have hobbies, travel, read books, and want to try new things.
- The discoverer can make use of the noticer and advisor, and can travel in space and time.

Curiosity, creativity, flexibility, and habits

The discoverer makes use of our ability to be curious and creative, and enhances our ability to innovate (\rightarrow p. 13, 136) and be flexible. Many anthropologists think that **curiosity and openness to novelty were important components that enabled cumulative cultural evolution** (\rightarrow p. 64 f.) in our species¹.

Our discoverer can be helpful for changing our **habits** - it is estimated that about 40-50% of our daily behaviors are habits² - forms of behavior that are largely driven by fast thinking (\rightarrow p. 110 ff.) and reinforcing feedback loops (\rightarrow p. 144). Because of this, once habits are established, changing them is not that easy. **Practicing our discoverer skills by regularly trying new things or exploring new environments** can help us be more flexible and intentional in the kinds of habits and behaviors we want to evolve in ourselves.



Our Mind

The Advisor

- Function: To use prior learning and language in order to learn from experience, simulate possibilities, and reduce the need for risky trial-and-error learning
- The advisor may be an evolved trait unique to humans (because of our ability for language and symbolic thinking).
- The advisor develops during our lives through relationships with other people and language learning. The things that people communicate to us in the course of our development, and the things we communicate to other people, become the repertoire from which our advisor continually builds our thoughts in unlimited combinations.
- The advisor is influenced by fast thinking (System 1), but it can also be controlled by us sometimes and to some degree (System 2). It often travels around in space and time. It does a lot of judging, evaluating, predicting, worrying, looking for causes and patterns.

Language and symbolic thinking

With language and symbols, our species is able to imagine and communicate about things beyond our immediate experience. This is great for motivating us to plan and prepare for tomorrow's hunt (or exam), for reminding us of unpleasant situations we faced earlier so we can learn from it, for telling others about what we have experienced so that they might learn from it, or to build a sense of belonging and common identity (\rightarrow p. 80). But **our ability for language and symbolic thinking also has a downside** - the way we use language to categorize and make sense of the world and the way we become "fused" with the interpretations in our mind can make us less flexible, affect our mental health, and lead to conflict. In this way, our Advisor can limit our Noticer and Discoverer skills.

"Although we humans have gained the ability to extract ourselves from the physical jungle, through language we are now recreating the danger of the jungle in our heads again and again."



Our Mind

Psychological Flexibility - Noticing, accepting, and using our mind for valued purposes

A lot of the time the behaviors of our mind are automatic (System 1) and we can not simply "turn them off" or "get rid of them", because they are part of our history and have important roles to play. So what can we do if one of the characters "wants" to dominate our perception and action, and is not being particularly useful?

We can learn to practice mindfulness - i.e. to **use our Noticer to observe the workings of the characters in our minds from a distance**. This way we notice how the characters, as well as our external environment, affect our present state, and how they want to direct our actions, but we do not necessarily have to follow their "orders".

"No matter how confusing, difficult, or busy life gets, we can always shift into noticer behavior and find our center and stability."

Hayes & Ciarrochi (2015), p. 17

In addition, we can learn to let our behavior be directed by what is really important and worth living for us, rather than by what the characters are currently proposing to us. We can learn to take the characters in our minds seriously when they are useful for achieving our goals, and to take them less seriously when they have nothing useful to offer.

Some psychologists call this ability "**psychological flexibility**"¹. It is the ability to accept and use the behaviors of our mind more flexibly, in the service of achieving our goals and living in line with the things we care about. Practicing psychological flexibility may be related to a variety of other competencies and attitudes like growth mindset, intellectual humility, or cooperation (\rightarrow p. 26 ff.).

¹e.g. Kashdan & Rottenberg (2010)



Values



In order to use the behaviors of our mind in more helpful ways, we have to first be aware of where we want to go, or how we want to be in the world.

Our values provide this guidance.

They are like a compass that **Cooperation Presure** shows us the direction of true **Cooperation Presure** north. No matter where we are, **Change Excellence Adventure Education** what we are doing, or what is **Contributing** happening to us, we can always **Creativity Interview** choose to "go North".



Even though we might come across the word "values" in our everyday language, we might not think much about what characterizes values. Through a set of reflection prompts, we can come to a deeper and helpful conceptual understanding of what values are, and how we can identify our own values in our everyday experience.

For example:

- Are values the same as goals? If not, how are they different?
- Are values the same as "having fun" or "feeling good"? If not, how are they different?
- How do we acquire our values? Do other people parents, teachers, the media etc. tell us what to value? How can we find our own values?

We can think of values as qualities of our everyday actions and experiences that make those actions and experiences worthwhile and meaningful in themselves¹. Research shows that clarifying our values can lead to many positive outcomes. For example, it can help us be more resilient and motivated in school², and can even increase our intellectual humility (\rightarrow p. 121) and prosocial attitudes when discussing complex issues with others³.



Our Mind

"Sometimes it is beneficial to be immersed in the present to appreciate the array of beauty walking through the neighborhood, the wisdom of what a person offers in conversation, or striving to finish a memo before the workday is over; sometimes it is beneficial to be positioned in the future, clarifying values, future goals to link with those values, and specific, planned behaviors to make progress toward those goals; sometimes it is beneficial to be in the past, whether it is savoring experiences for a mood boost, re-connecting with one's personal history, extracting life lessons, or working to synthesize and create coherence from a variety of interesting experiences. (...) If these examples suggest anything, it is that greater satisfaction and meaning in life can be captured by shifting temporal perspectives when the situation requires a particular mode of being."

Kashdan & Rottenberg (2010), p. 868

"Sometimes negative, unpleasant emotions can be more useful than positive emotions. Taking advantage of this knowledge, teaching people this knowledge, is to explicitly address psychological flexibility."

Kashdan & Rottenberg (2010), p. 867

"Imagine if we could teach young people to become mindful of the ways that symbols can dominate our interpretations of experience and can become unhelpful. They might then learn to use symbols like tools, and "put them down" when no longer useful. They might become less caught up in self-criticism, materialism and prejudice. Could they pass these lessons on to their children? Or imagine if all young people learned to judge their behavior in terms of how it served their values, and especially how it helped them build connection and love. Or imagine young people who understood that they are not fixed, and the future is not fixed, and they can improve themselves and this world. What might they teach their children?"

Ciarrochi & Hayes (2018), p. 121





Global Sustainability Goals

How do our human behaviors impact the various aspects of sustainable development? To what extent can our human characteristics be obstacles and opportunities to coping with these challenges? How can we use our understandings about human evolution and behavior to analyze and solve real world problems?







Global Sustainability Goals

Mismatch?



When adaptations to previous environmental conditions are no longer adaptive under the given environmental conditions, biologists describe this as an instance of **evolutionary mismatch**. Are today's problems of human well-being and sustainable development an indication of such a mismatch between our evolved traits and the modern environment?

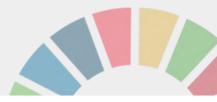
After all, **cultural evolution** (\rightarrow p. 12 f., 64 f., 82, 85) has fundamentally changed the social and natural environment of humans. These changes are becoming ever more drastic with the rise of new technologies. Do we have a "stone-age brain" that can not cope with these changes?

On the other hand, a special cultural flexibility characterizes our species: we humans, especially our perception, behaviors, beliefs, norms, and other cultural traits are less influenced by genetic inheritance, and more influenced by cultural inheritance (\rightarrow p. 67, 69, 85 ff.). What was normal for the previous generation may be unthinkable and unacceptable to the next generation, and vice versa. **Our cultural evolution goes hand in hand with the flexibility of our species**.

To what extent **can we use our understanding of the complex causes of our human characteristics** to address the challenges of sustainable development, to avoid the effects of potential mismatches, to **adapt our behaviors and cultures towards valued living** in the 21st century?

"As societies globalize and human-induced environmental change occurs progressively faster, evolutionary mismatch is only becoming increasingly prevalent. Given that mismatch often brings negative consequences for physical and psychological health and values, understanding the mismatch process is important not only for basic psychological science research but also for achieving key insights into more effective avenues to address the numerous problems of the modern world."

Li et al. (2018)





Global Sustainability Goals

The concepts and human behaviors explored across the content anchors show us that some of the human characteristics emerging through biological and cultural evolution as well as individual development may present particular obstacles to human well-being and sustainable development, for example:

- ♦ While we are a highly cooperative social species, we intuitively divide our social environment into various groups, leading us to collaborate within "our" group, yet at the same time to differentiate ourselves from other humans, and this can sometimes have positive or sometimes negative effects for ourselves and others (→ p. 67, 80, 118 f.).
- ★ Many of our perceptions and behaviors are influenced by cognitive biases, (moral) intuitions, (social) emotions, and social norms in a way that we are often unaware of. This can sometimes have positive or sometimes negative effects for ourselves and others (→ p. 110 ff.).
- ♦ Mental time travel (→ p. 122 f.) can make us experience negative experiences from the past - this can help us learn from experience, but can also make us worry too much about the (imagined) future. It can affect our well-being and behavior in the here-and-now in ways that are not helpful.
- Symbols and language greatly shape our perception. Our "advisor" (→ p. 126) can give us too much useless advice or too many negative evaluations (about ourselves, our life, other people, our circumstances). It can affect our well-being and behavior in ways that are not helpful.

Psychologists, anthropologists, and behavioral scientists have recognized that these human behaviors under today's environmental conditions are significantly linked to problems such as unhealthy lifestyles, stress and depression, social isolation, (cyber-)bullying, materialism, nationalism and xenophobia, social conflicts over ethical and moral affairs, and social inequality.





Global Sustainability Goals

However, the content anchors also help us understand how certain conditions and causal relationships can promote or hinder the development of all these human abilities, motivations, and behaviors, and ultimately human well-being.

Many behavioral scientists are concerned with using this knowledge in a way that allows us to change our behaviors and (social, natural) environmental conditions, so that they may promote human well-being and the sustainable development of our species and our world:

- Which conditions promote or endanger human well-being, learning, flexibility, and cooperation? Can (and should) we shape environmental conditions in a way that they promote people's abilities and motivations to learn from each other, be flexible, work together and to act in their everyday lives in accordance with goals of human well-being and sustainability?
- Which behaviors promote or endanger human well-being, learning, flexibility, and cooperation? Can (and should) we help humans to develop these behaviors, attitudes, and skills? Can we support humans in becoming more aware of their intuitions, emotions, behaviors, and values, and to understand the causes and consequences of these? Might this understanding support them in persisting in the face of challenging circumstances and in building shared identities with other humans?
- What role can (and should) our technologies, policies and regulations, social norms, media, and education play in creating these environmental conditions and in promoting these skills? Would a more broadly shared understanding of what it means to be human change how we discuss these aspects of society?



Global Sustainability Goals

"All in the same boat"?



The many topics from the content anchors show us that humans have the ability and the motivation to tackle the multifaceted challenges of collaboration in ever larger groups, by identifying shared interests, common values and goals, learning from and teaching each other, communicating, finding common solutions, developing common norms and institutions, and committing to safeguarding their social and natural environment. In fact, these abilities and motivations seem to distinguish us as a species - they make us human.

However, because of the interrelationships in a globalized world and the impact of our behaviors on global ecosystems today, global society ultimately "sits in one boat". We are part of a global public goods game (\rightarrow p. 91 f.) in which the rules are not (yet) clearly defined, and in which mistrust and uncertainty prevail.

In this situation, it is a challenge to align the interests of individuals (including individual groups) with the interests of the global community. The potential for selfish behavior, competition, and conflict is high. Social inequality, the rigidity of international negotiations, political and economic abuse of power, rise of nationalist movements, and serious disagreements on complex societal issues are the consequences that we can observe today, which hinder the achievement of global sustainability goals.

"We suggest that some of the key difficulties of global governance stem from a period of transition in which reciprocity, trust, communication, reputation, enforcement, we-identity and fairness need to be re-negotiated, re-established, or even reinvented."

Messner, Guarín, & Haun (2013)





Global Sustainability Goals

Our ability to create a common identity with many people has been, in the history of our species, associated with a demarcation of "the others" (\rightarrow p. 80, 118). This factor continues to shape discussions and disagreements around the "right" priorities and solutions for sustainable development. How can we create a global identity that is not endangered by such groupish thinking? How can we create shared values and understandings that transcend cultural differences?

"Since states first appeared c. 5000 years ago, their maximum size has been gradually increasing. (...) But does it mean that the trend to ever larger states will continue and a global state is inevitable? Up until the present the force driving the evolution of increased social scale has always been competition/conflict in opposition to some other societies. If the global state were to arise, where will it find the external threat that would keep it unified? (...) On the other hand, neither history nor evolution is destiny. Humans have transcended their evolutionary limitations before. (...) We just should not expect this to happen automatically, simply as a result of a 5,000-year trend of increasing state size."

Turchin & Gavrilets (2009)

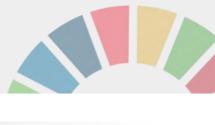
"(T)he best way to motivate people to collaborate and to think like a group is to identify an enemy and charge that "they" threaten "us." (....) Such group-mindedness in cooperation is, perhaps ironically, a major cause of strife and suffering in the world today. The solution—more easily described than attained—is to find new ways to define the group."

Tomasello (2009)

"Our moral brains, which do a reasonably good job of enabling cooperation within groups (Me vs. Us), are not nearly as good at enabling cooperation between groups (Us vs. Them). [...] biologically speaking, our brains were designed for within-group cooperation and between group-competition. Cooperation between groups is thwarted by tribalism, disagreements over the proper terms of cooperation, (...), a biased sense of fairness, and a biased perception of the facts."

Greene (2013), p. 148





Global Sustainability Goals



Innovation and collective learning

Our societies are locked in a cultural system that depends on and reinforces the use of certain kinds of technologies and materials fuelled by fossil fuels. While technological innovation alone is not going to solve our complex sustainability challenges, it is certainly an important pillar.

Luckily, a hallmark of our species is our ability to learn from each other and create innovations that neither of us could create alone ($\rightarrow p. 64 \text{ f.}$).

"We (...) argue that innovations, large or small, do not require heroic geniuses any more than your thoughts hinge on a particular neuron. Rather, just as thoughts are an emergent property of neurons firing in our neural networks, innovations arise as an emergent consequence of our species' psychology applied within our societies and social networks. "

Muthukrishna & Henrich (2016)

How can we accelerate this innovation capacity of our species to develop more sustainable technologies and forms of social organization? Cultural evolution scientists find that the more people are connected, the better we can share information with each other, and the more diverse we are, the higher the rates of innovation¹. So how can we enable ever more people to connect to our "collective brain", how can we encourage and be open to cultural diversity, in order to foster innovation?

"The rate of innovation (...) is a function of (1) a society's size and interconnectedness (sociality), which affects the number of models available for learning; (2) fidelity of information transmission, which affects how much information is lost during social learning; and (3) cultural trait diversity, which affects the range of possible solutions available for recombination... all three levers can increase and harm innovation by creating challenges around coordination, conformity and communication"

Schimmelpfennig et al. (2021)

¹ Muthukrishna & Henrich (2016)





Human well-being



Sustainability is about ensuring well-being and valued living of humans and other creatures. But what is well-being? How would you define it, and what factors and behaviors contribute to or diminish it?

Scientists have found that the ideas people have about well-being actually impact their experienced well-being¹. People that associate well-being with experiences of pleasure tend to experience less well-being compared to people who associate well-being with self-development and working to contribute to the greater good.

Connected to the concept of well-being is also the idea of human **needs**, both material and psychological. Many of these human needs are represented in the global Sustainable Development Goals. Several researchers have tried to develop a list of human basic **psychological needs**. Candidates include **autonomy; competence; belonging/connection; meaning/purpose; feeling and experiencing**². To what degree do communities, including schools, fulfill these needs of their students, teachers, and other stakeholders?

Scientists have also found that there seem to be a number of **activities** that humans can engage in **that contribute to the fulfillment of their needs and sense of well-being**³:

- connecting with others (family, friends, romantic, ...)
- giving to others and having a positive influence (community, citizenship,...)
- being active
- embracing the moment
- challenging ourselves and learning
- caring for ourselves



Global Sustainability Goals

Schools fit for humans?

A hallmark of our species is our ability and motivation for social learning and teaching (\rightarrow p. 77). Humans appear to be born with a drive to be curious and explore the world on their own, and to learn the social norms, language, knowledge, and beliefs of their culture simply by being around other people and a cultural environment (\rightarrow p. 87).

Anthropologists suggest that enhanced teaching may have co-evolved with the onset of more complex tools about 2 million years ago¹. Against this background, schools and formal education are a very recent cultural invention.

So what would a school "fit for humans" look like in today's world? Is our current education system mismatched to our "natural" ways of teaching and learning? Does it make sense to model our schools by how humans learned during a time that was much less complex, did not have the internet or Al technologies, and did not entail global exchange and mixing of cultures and ideas? Or are there aspects of our evolved needs, motivations, and abilities that modern education systems need to more strongly take into account and cater to? What can we learn from the diversity of schools around the world (\rightarrow p. 87)?

"[O]ur hunter-gatherer educative instincts are quite adequate for education today, given an appropriate educational environment. The ideal environment for such education [...] is one in which young people (a) have unlimited free time and much space in which to play and explore; (b) can mix freely with other children of all ages; (c) have access to a variety of knowledgeable and caring adults; (d) have access to culturally relevant tools and equipment and are free to play and explore with those items; (e) are free to express and debate any ideas that they wish to express and debate; (f) are free from bullying (which includes freedom from being ordered around arbitrarily by adults); and (g) have a true voice in the group's decision-making process."

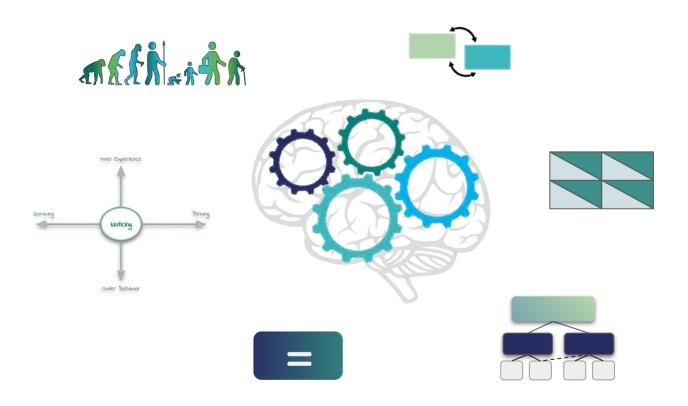
Gray (2011)

¹e.g. Csibra & Gergely (2011); Morgan et al. (2015)



Various strategies and methods can be used in the classroom to explore particular human behaviors or sustainability issues. In our design concept, we have integrated a range of such strategies and methods we call "thinking tools". They are informed by the evolutionary, behavioral, and sustainability sciences. They can help students to develop the skills that scientists use in analyzing the causes and consequences of human behavior, and the complex relationships in social-ecological systems, as well as for integrating perspectives from several disciplines and building deeper theoretical understandings.

Thinking tools can be used across diverse lessons, which promotes transfer of learning across themes in evolution, behavior, and sustainability science.



Thinking Tools Tinbergen's Questions



... to explore different causes of behavior

Behavioral biologists (or ethologists) explore the causes of behavior in humans and animals. On the one hand, we can look for causes of behavior in the past what happened before the event and contributed to the expression of a behavior? Some causes are about immediate factors, others about more recent factors such as events in individual development, and others are in the history of a population. On the other hand, we need to look at the function of a behavior - what function and what consequences does the behavior have for the behavior itself, for the individual organisms, and for their environment?

The behavioral biologist **Nikolaas Tinbergen** (1907-1988) was particularly influential for dividing these different causes into four different types¹:

- Immediate triggers and proximate physiological mechanisms
- Causes in the development of individuals
- Causes in evolutionary history
- Causes that are related to the function or adaptive value of the behavior and that cause an individual to repeat the behavior (or not), or that lead to the behavior becoming more or less common in a population.

Tinbergen's questions have been modified and reorganized over the years by many other scientists. For example, scientists that are interested in human behavior have added culture or cultural history as important causes of human behavior. Psychologists and social scientists have also suggested to include human goals and values as proximate causes (of course they are also behaviors whose causes can be explored), and to expand the meaning of "function" and "adaptive value", beyond mere survival, to flourishing².

With these and other additions, we have arrived at a reorganization of Tinbergen's questions shown on the following page. On the one hand, we can look for different kinds of causes by going back in time. On the other hand, we can always ask why the behavior persisted - what functions did it have and what contributed to its persistence in the population or in the individual - such that we can observe it today.

¹ Tinbergen (1963) ² Ariew & Panchanathan (2023)

Thinking Tools Tinbergen's Questions



... to explore different causes of behavior

The following overview can support the implicit or explicit classification of different causes of a behavior in the classroom. We can engage content from across the content anchors to explore specific types of causes.

behavior	servable trait/ r/phenomenon in logy/society	How does it work? What triggered it? Where did it come from? When did it come about?	What outcomes does it create? Why does it exist today? (function, adaptive value)
Proximate past	Mechanism(s) milliseconds, seconds, minutes, hours, days before	Internal: sensing and perception of environmental stimuli, neural networks, brain areas, neurotransmitters, hormones, affect/emotions, thoughts, goals, System 1, System 2, gene expression External: stimuli in the social, cultural, biotic, abiotic environment	How does the observed trait function in its context regarding its survival/retention/ reinforcement/ transmission/ reproduction and/or in relation to human values?
	Development months, years, decades before Family history decades, centuries	Internal: experiences, learning, memories, habits, maternal effects, epigenetics, genes External: social, cultural, biotic, abiotic environment	How has the trait and its development functioned over life history regarding its survival/retention/ reinforcement/ transmission/ reproduction and/or in relation to human values?
I I I Distant past	Cultural history decades, centuries, millennia before Evolutionary history thousands, millions of years before	Internal: genes, epigenetics, developmental processes, homological structures and functions External: social, cultural, biotic, abiotic environment	How has the trait and its development functioned over (cultural and) evolutionary history regarding its survival/retention/ reinforcement/ transmission/ reproduction and/or in relation to human values?

Thinking Tools Tinbergen's Questions



... to explore different causes of behavior

So behavioral biologists are aware that behaviors have many complementary causes. If we want to understand our own behavior and the behaviors of others, it is a good idea to explore these different causes.

"There are few clear-cut causal agents - so don't count on there being **the** brain region, **the** neurotransmitter, **the** gene, **the** cultural influence, or **the** single anything that explains a behavior."

Sapolsky (2018), p. 386

"A behavior has just occurred. Why did it happen? Your first category of explanation is going to be a neurological one. What went on in that person's brain a second before the behavior happened? Now pull out to a slightly larger field of vision, your next category of explanation, a little earlier in time. What sight, sound, or smell in the previous seconds to minutes triggered the nervous system to produce that behavior? On to the next explanatory category. What hormones acted hours to days earlier to change how responsive that individual was to the sensory stimuli that trigger the nervous system to produce the behavior? And by now you've increased your field of vision to be thinking about neurobiology and the sensory world of our environment and short-term endocrinology in trying to explain what happened.

And you just keep expanding. What features of the environment in the prior weeks to years changed the structure and function of that person's brain and thus changed how it responded to those hormones and environmental stimuli? Then you go further back to the childhood of the individual, their fetal environment, then their genetic makeup. And then you increase the view to encompass factors larger than that one individual - how has culture shaped the behavior of people living in that individual's group? - what ecological factors helped shape that culture expanding and expanding until considering events umpteen millenia ago and the evolution of that behavior."

Sapolsky (2018), p. 6, 7

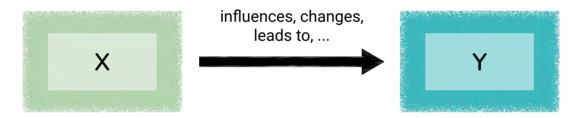
Thinking Tools Causal Mapping



... to illustrate complex causal relationships

Evolution does not stop: Causal relationships between our behaviors, our well-being, our social and natural environment, and our cultural institutions and technologies have shaped us as a species and as individuals, shape our present, and continue to shape our future. These interactions are often complex and extend over larger dimensions of time and space. So, the effects of our actions are often not what we expect them or would like them to be. Sustainable development requires that we **understand these causal relationships**, so that we can **influence them in a direction that we all want**.

Causal maps or causal diagrams are used in science and education to investigate and illustrate cause-and-effect relationships. In causal maps, traits, conditions or other variables and factors are linked by arrows that indicate a kind of causal relationship - X influences, changes, or leads to Y.



These causal relationships can be of different types. The concrete nature of a causal link can be stated if it is known or assumed, or it can remain general when the aim is to explore, discuss, or reflect on it.

For example, "is consumed by" is a causal relationship in a food web of an ecosystem. Natural selection is a kind of causal relationship in which a condition *leads to an increase in the frequency of a trait in the population*. Depending on the trait, different selection and inheritance mechanisms can be at work, e.g. biological reproduction or imitation (\rightarrow p. 13).

When three or more factors are linked by causal relationships, it becomes more and more difficult to predict the consequences of these interactions - one speaks of **complex causal interactions**.

Complex systems are characterized by such complex causal relationships. We find them in many areas, e.g. **in biology, ecology, psychology, and society**.

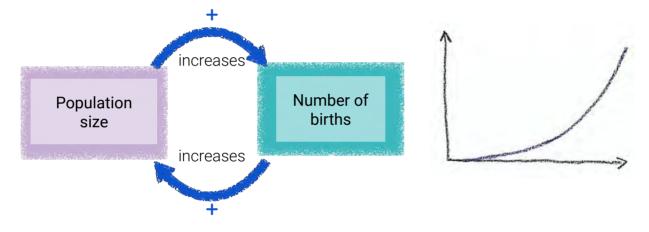
Thinking Tools Causal Mapping



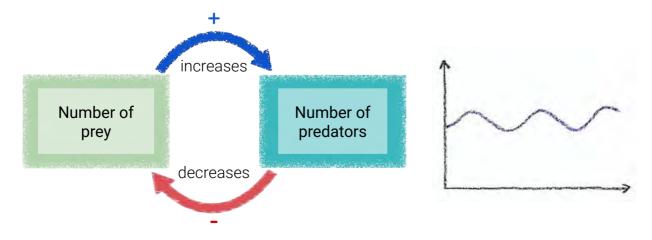
... to illustrate complex causal relationships

Among the interactions in complex systems one often finds "feedback loops". In feedback loops, there is not only a link from cause to effect, but also a link from effect back to the cause. Feedback loops play a key role in the change (or stability) of complex systems.

Positive (reinforcing) feedback loops are processes that reinforce themselves - the more of something there is, the more of it is produced, or the less of something there is, the less of it is produced. Examples are the exponential growth of a population, or the dynamic of an arm's race. The formation and maintenance of habits is also driven by reinforcing feedback loops and the brain's reward system.



Negative (balancing) feedback loops are processes that dampen and balance themselves the more of something there is, the less of it is produced, or vice versa. An example is the interaction between predator and prey populations. Negative feedback can cause systems, e.g. living organisms and ecosystems, to regulate themselves (without a central leader). Many regulatory processes of our body are therefore examples of negative feedback loops.

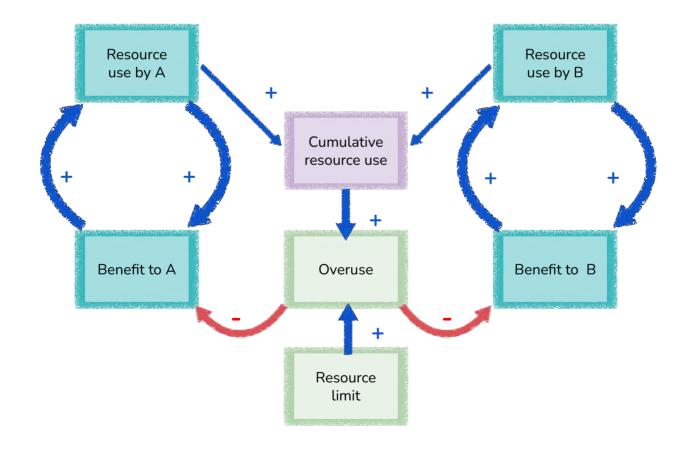


... to illustrate complex causal relationships

System archetypes

System archetypes are system structures that we find in many different situations and that produce characteristic system behaviors¹. They also appear to be involved in many sustainability challenges and can help us think about their causes and solutions². Identifying system archetypes across diverse phenomena with the help of causal maps is a great way to develop deeper conceptual understandings and systems thinking competencies in learners.

There are several different system archetypes that complex systems scientists have identified. One such system archetype is the **Tragedy of the Commons** (\rightarrow p. 7), which we can represent in a causal map in the following way.



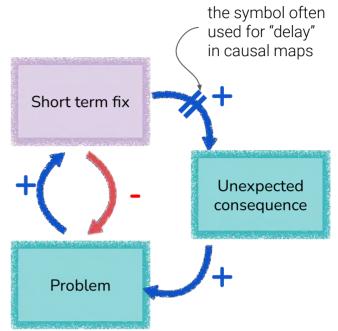




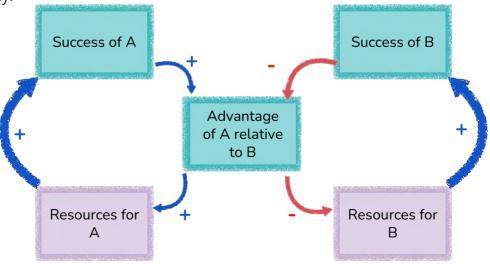
... to illustrate complex causal relationships

Other system archetypes are called "Fixes that fail" and "Shifting the burden". They describe how we might often engage in short-term fixes of problems, which can create unintended consequences and new problems.

In fact, such a dynamic can happen in ourselves, as when developing an addiction or in procrastination. The Noticing Tool (\rightarrow p. 153) is a way to be aware of these dynamics in ourselves and to disrupt them by focusing on our values rather than short-term and reactionary fixes.



Another system archetype is called "Success to the successful", and it underlies many challenges of social equality. The rich get richer, and the poor get poorer, the powerful attain still more power, the better performing students get more attention and opportunities and thus perform still better, and so on. Being aware of this system dynamic can help us reflect on how different kinds of fairness norms (\rightarrow p. 86) might reinforce or help disrupt such vicious cycles of increasing inequality.

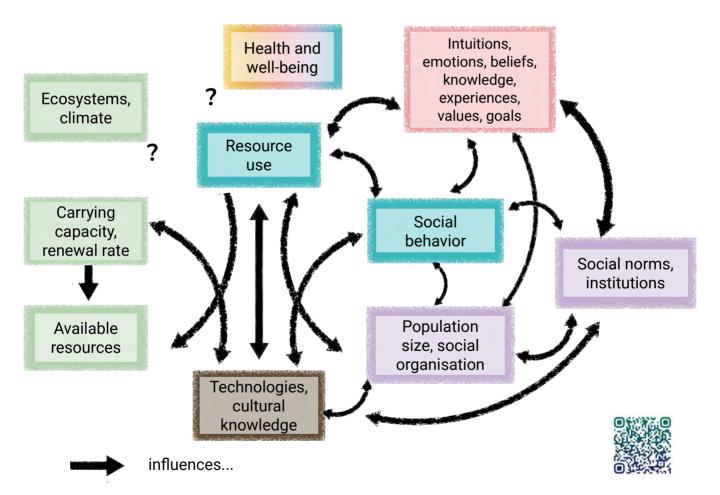






... to illustrate complex causal relationships

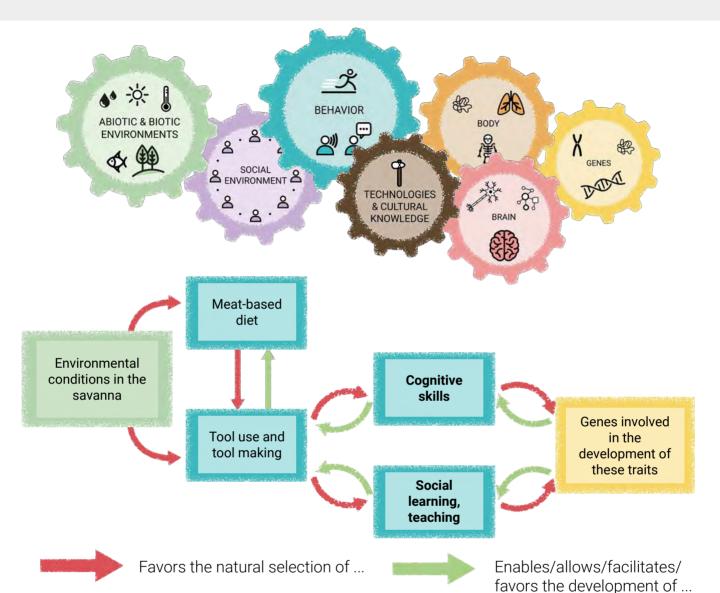
Particularly the development of our global social-ecological system is characterized by feedback loops that arise from the interplay between environmental conditions, our technologies and institutions, and the behaviors and social interactions of individuals. Hence many drastic changes today - such as population growth, resource consumption, climate change, and technological innovation - are the result of these feedback loops. Some of the outcomes they produce we deem to be "good" - they are helpful for achieving our common goals. Other outcomes they produce we deem "bad" - they present challenges in achieving our common goals.



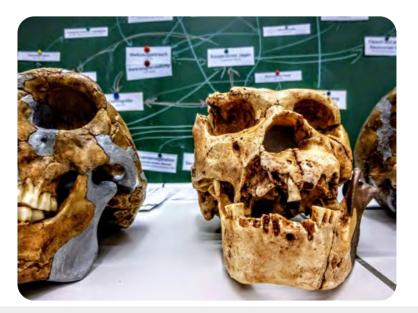
How do our social and natural environment, our behaviors, our perceptions influence each other? Causal maps allow teachers and students to reflect on concrete relationships between these factors in specific contexts and to discuss leverage points - places where we can effectively change the evolution of these interacting factors, both individually, and as a community.



 \ldots to illustrate causal relationships in the evolution and development of ${\rm traits}^1$



¹ see also Hanisch & Eirdosh (2020)



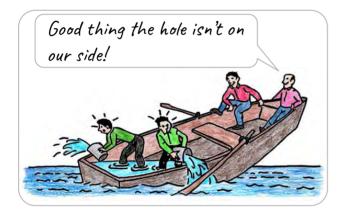
Thinking Tools Payoff Matrices



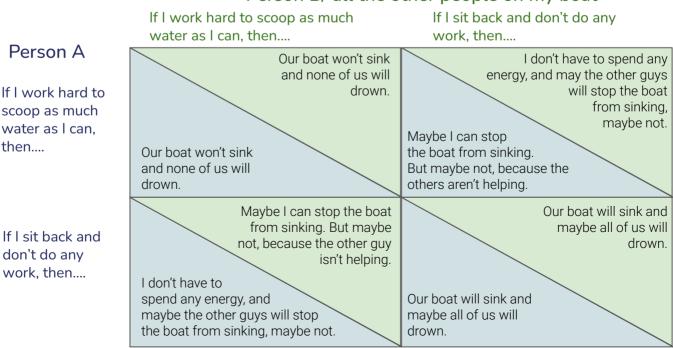
... to explore the motivations and outcomes of human behaviors in particular situations

Many situations in our everyday experience are **social interactions** - outcomes for us are not just influenced by how *we* behave individually, but also by how *others* around us behave. This is because we humans live in social groups and in a world that is changed and created by other humans. When we are all in the same boat, the way others on our boat behave can have outcomes for us.

Evolutionary biologists, economists and sustainability scientists sometimes represent the costs and benefits that people (or other animals) get from a behavior through a so-called **payoff matrix**. Using payoff matrices in the classroom helps us reflect on the possible motivations and consequences of behaviors in particular situations, especially in social interactions.



What motivates the red guys in this boat to not help the green guys? What motivates the green guys to work so hard? What might be the outcome of each person's behavior for everyone in the boat? Can outcomes of a behavior be different in the short-term and in the long-term?



Person B/ all the other people on my boat

Thinking Tools Payoff Matrices



... to explore the motivations and outcomes of human behaviors in particular situations

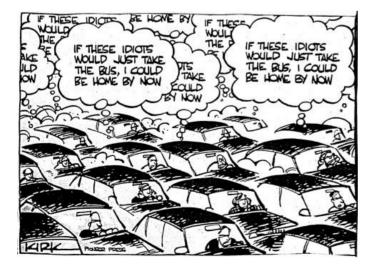
Payoff matrices help to **identify whether there is a social interaction between individuals**. This helps us understand the level or size of group we need to look at in order to understand the causes and outcomes of behaviors in a social-ecological system.

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 (\rightarrow p. 7 ff.).

Social dilemmas seem to be at the heart of sustainability challenges. Sustainability scientist explore how we can solve such dilemmas by finding ways to align the interests of individuals with the interests of the whole group.

Some essential questions that the payoff matrix helps explore:

- What motivates humans to behave in a certain way in a certain situation? What is the role of intuitions, emotions, beliefs, socio-economic context, personal preferences and goals, and learned social norms?
- What outcomes does a behavior create in a certain context, for the individual as well as for others?
- Can benefits and other consequences of a behavior be different between the short-term and the long-term? Is there a dilemma between short-term motivations of individuals and long-term benefit for everyone?



What motivates all these people to take the car? Why does no one take the bus?

What is the outcome of everyone taking the car or the bus, in the short-term and in the long-term, for individuals, for the community, and for their environment?

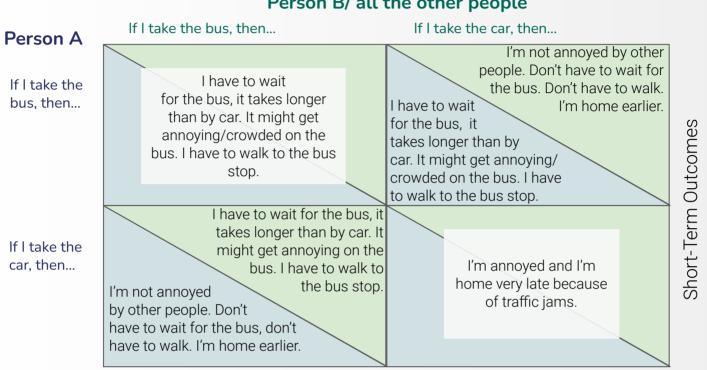
What could we do to nudge (\rightarrow p. 94) or empower people to behave more in line with their long-term interests and values?

Thinking Tools

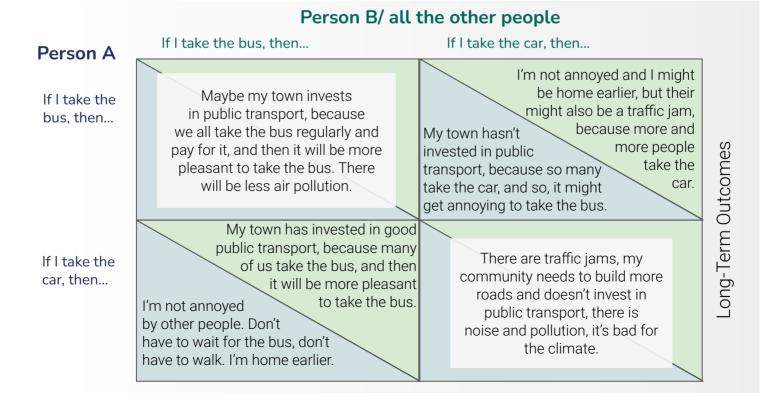


Payoff Matrices

... to explore the motivations and outcomes of human behaviors in particular situations



Is there a dilemma between the short-term motivations of individuals and the long-term benefits for everyone?

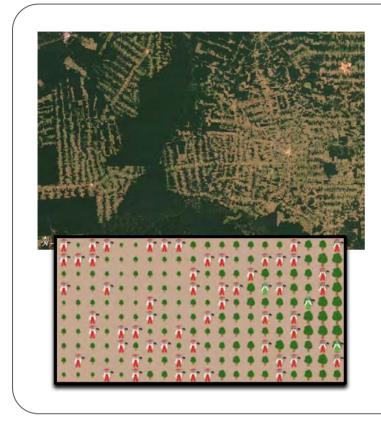


Person B/ all the other people

Thinking Tools Payoff Matrices

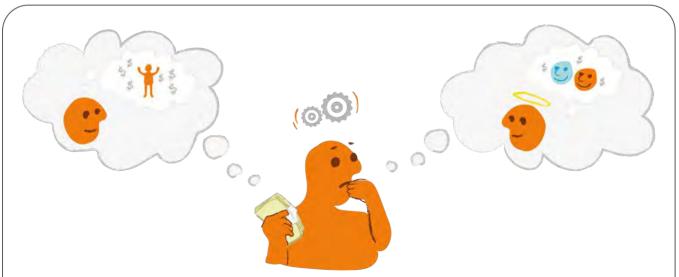


... to explore the motivations and outcomes of human behaviors in particular situations



What motivates people to clear forest for a field? Might individuals be motivated to clear a smaller patch of land than their neighbors? Why, or why not?

What are the outcomes of everyone's behavior in the short-term and in the long-term, for individuals, for the community, and for the forest?



What motivates players in the ultimatum game (\rightarrow p. 90) to keep all the money? What motivates players to share a fair amount to a stranger? What motivates the partner to accept or refuse the offered amount? What are the outcomes of everyone's behavior?

Thinking Tools Noticing Tool



... to be aware of and interpret our own ongoing behaviors and experiences

Whereas Tinbergen's questions focus more on the immediate to distant past, the Noticing Tool mostly focuses on the present and the future. It also helps us apply many behavioral concepts to our own everyday experiences.

The Noticing Tool¹ (see the following page) distinguishes two dimensions of experience:

- A dimension of **surviving vs. thriving**. This dimension encapsulates two core functions of behavior in all organisms protecting ourselves from dangerous situations (e.g. by avoiding, leaving, or fighting them), and moving us towards new situations that provide new opportunities and help us thrive. We may often find ourselves in survival-mode, even when we aren't confronted with life or death situations. For example, when we want to avoid an uncomfortable feeling. Surviving is important, but it is not what we understand by a good life. A good life is *also* full of thriving, having a purpose, living in accordance to one's values. When are we in survival mode and when are we in thriving mode, and how does it feel?
- A dimension of inner vs. outer behavior. This dimension distinguishes between things we do with our body, and things we do or experience inside of us, such as thoughts, feelings and bodily sensations (→ p. 14 ff.). This dimension can help us be more aware of our inner behaviors and their influence on how we perceive, interpret, and react to the world.

Combining these two dimensions gives us four quadrants that ask us to notice what it means for us to thrive, the inner behaviors that show up and want to protect us, and what we might do in the world in response to those inner aspects of experience.

We can use the Noticing Tool at any (waking) moment in order to check in with what is going on, what we are doing and who we want to be in this moment or in the future. It can therefore be a **tool to practice and refine our skills** for **mindfulness** (\rightarrow p. 124), **self-regulation**, growth mindset, intellectual humility, **cooperation**, as well as many other competencies that entail an **awareness**, **reflection on and metacognitive reorientation of our own behaviors**.

¹ adapted from Atkins et al. (2019); Martinez (2023); Polk & Schoendorff (2014)

Thinking Tools Noticing Tool



... to be aware of and interpret our own ongoing behaviors and experiences

Inner Experience & Behavior (what others can't see; what is happening in my mind and body)

2) What appears in me/us and tends to take me/us away from (1)? (feelings, thoughts, sensations ...) "It's too difficult!" "I always do all the work!" "What's the point!" "I'm just too stupid for that!"

Boredom, Frustration, Anger, Fear, Anxiety, Sadness 1) What is important to me/us? Why am I/are we here? Who do I/we want to be, what do I/we what to stand for? [values, goals, needs] *Being a good friend*

Achieving something with others Being physically active Learning and being curious Being honest

Surviving

Noticing

Thriving

3) What do I/we do when experiencing (2) that takes me/us away from (1)? Not doing homework Giving up Getting mad at my friend Getting mad at my teacher Keeping quiet Not joining the new school club Going shopping 4) What can I/we do to live towards (1) - even if (2) shows up?

ask my classmate why he's upset; tell my teacher why I'm frustrated; ask someone for help with a task; join the new school club even if I'm nervous; going for a walk

Outward Behaviors (what others can see or hear me do; what I do with my body)





... for the development of networked and transferable understandings

"Analogy [is] the fuel and fire of thinking."

Hofstadter & Sander (2013)

This guide, and the behavioral sciences, are full of analogies and analogical reasoning. Behavioral experiments, games, and computer models are also analogies to the real-world phenomena they aim to represent.

In the classroom, analogies and analogical comparisons can guide students to transfer their developing understandings across content, including to everyday and societal issues, and to critically evaluate results of behavioral experiments and models. For example:

- What are the similarities and differences between the conditions and observable behaviors in a behavioral experiment or simulation game and the conditions and observable behaviors in the real world?
- What are the similarities and differences between the processes and outcomes of a computer model and the real world?
- ♦ What are the similarities and differences between biological evolution, cultural evolution, and learning? (→ p. 13)
- What are the similarities and differences between different sustainability problems in the world?

Analogy maps can help us to reflect on answers to these questions. In analogy maps, two or more phenomena are compared by overarching principles.

Overarching principles, processes, conditions, behaviors	Phenomenon X	Phenomenon Y
••••		



... for the development of networked and transferable understandings

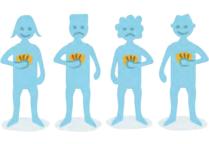
"All in the same boat"? $\rightarrow p. 7, 8$



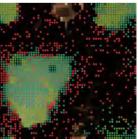
For any given sustainability question, we can ask: to what degree are we all in the same boat? To what extent are the interests of individuals in line or opposed? To what degree does it matter that we are in the same boat? Where does the boat analogy break down?

Experiments, cooperation games, computer models $\rightarrow p. 88 \text{ ff.} \rightarrow p. 98 \text{ ff.}$









What are the similarities and differences in the conditions in experiments, cooperation games, models, and in the real world? Can we transfer insights to real world challenges of sustainable development?



... for the development of networked and transferable understandings

Honeybee "democracy"? \rightarrow p. 56 ff.

What are the similarities and differences between the conditions, processes, and behaviors in the decision making of a honeybee colony and decision-making among human groups? How can we implement the principles of collective decision making in different human groups?

Principles for democratic decision-making	Honeybee swarm	Our school	Our country
Common goal(s) or shared interests			
Low influence of a central leader			
Diverse and independent experiences and perspectives			
Open exchange of views			
Consensus building			

"Moral taste buds"? \rightarrow p. 116 ff.

In what ways are the causes and functions of human taste buds similar to and different from the causes and functions of human moral intuitions? Does an understanding of these aspects help us engage our moral differences more flexibly?

Principles	Taste buds	"Moral taste buds"
Evolutionary origins		
Functions		



... for the development of networked and transferable understandings

Transferring principles of cooperation across contexts (\rightarrow p. 97):

What are the similarities and differences in the conditions, challenges, and capabilities for solving sustainability problems at different levels of society and even across species? How can we implement overarching principles of cooperation in different human communities?

Design Principle	Our project group	Global climate change	Analogous biological examples
0. Shared understanding			Communication about the quality of nest sites in a honeybee swarm
1. Shared goals and identity			Skin and cell membranes; fitness interdependence through factors such as physical proximity and genetic relatedness
2. Fair distribution of costs and benefits			Need-based transfer of resources (e.g., 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 behaviours			
6. Fast and fair conflict resolution			
 7. Autonomy to self-govern 8. Cooperative relations 			Becomes relevant when higher levels of selection emerge (e.g., endosymbiosis, multicellular organisms, social groups)
with other groups			

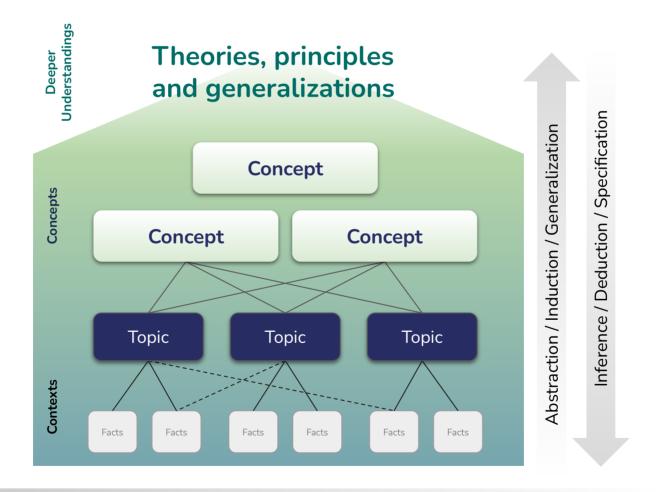
Source: adapted from Hanisch et al. (2023)

Thinking Tools Structure of Knowledge Diagrams



... for the development of networked and transferable understandings

Similar to analogy maps, structure of knowledge diagrams¹ help us clarify the nature of our own conceptual thinking, and that of others. They are a kind of concept map in which rather concrete facts, events, contexts, or phenomena are linked to more and more abstract and general concepts, to generalizations, principles, and theories made up of several concepts. They highlight that knowledge is more than a collection of facts. Curriculum reforms have increasingly emphasized this role of higher concepts in learning. Students need to be supported to discover and reconstruct these structures of knowledge so that they can use them to analyze new situations.

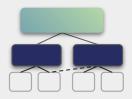


"Getting the big picture first (...) and then using that framework to fill in the gaps of specific knowledge is a distinctively human mode of learning. It figures prominently in children's development and scientific progress ..."

Tenenbaum et al. (2011)

¹ Adapted from Stern et al. (2017) based on work of Erickson et al. (2017); Hanisch & Eirdosh (2023b)

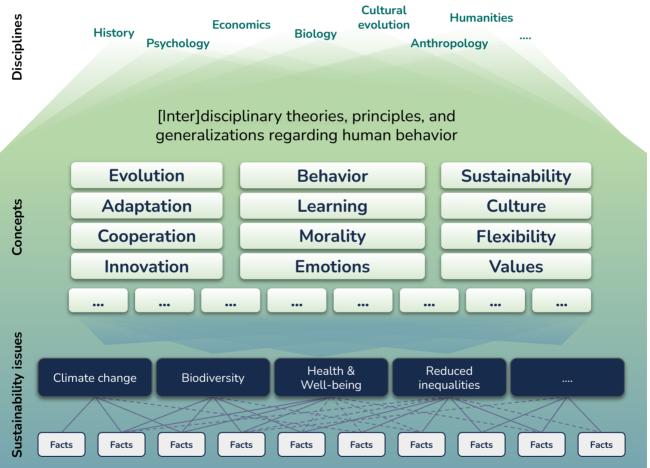
Thinking Tools Structure of Knowledge Diagrams



... for the development of networked and transferable understandings

Importantly - there is **no one "right" structure of knowledge**. Just like microscopes, telescopes, or maps are useful for exploring certain phenomena for particular purposes, so particular structures of knowledge are helpful for certain goals of understanding. Especially for understanding human behavior and issues of sustainable development, structure of knowledge diagrams can help to integrate and link concepts from many disciplines.

Human behavioral sciences



"Students need to understand conceptual relationships within and across disciplines to tackle our world's most pressing problems. Every conceptual structure that students recognize can become a new tool on their problem-solving utility belt."

Stern et al. (2021), p. 19

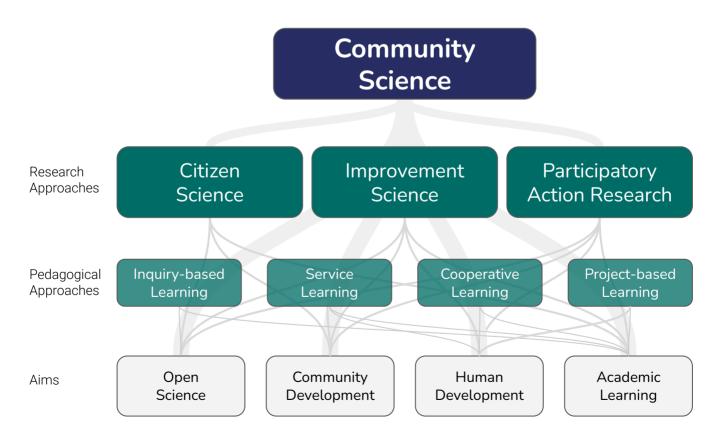
Community Science

Applying our understanding of human behavior and evolution for addressing real-world problems

Education for sustainable development is not just about the reorientation of curriculum goals, content, and pedagogy, but also the reorganization of schools as institutions towards sustainable development. The term "whole school approach" or "whole institution approach" is often used to describe this focus area of education for sustainable development.

As part of our educational innovation work, we are developing tools and guidance for school-based **Community Science Labs** as participatory improvement spaces in which students and teachers are empowered to use scientific and community-based methods to apply their understanding of the human condition for the advancement of a preferred future¹.

Community Science combines participatory research approaches with pedagogical approaches with the aim to foster learning, scientific inquiry, and the ability of communities to understand and address real-world community challenges.



Community Science

Applying our understanding of human behavior and evolution for addressing real-world problems

Schools, like any community, have many potential goals, values, and areas of improvement. The school portrait model below offers a general framework for a holistic view on school improvement. It can be used to help school community scientists identify themes of investigation and share insights with others. Importantly, we regard the development of school-based Community Science Labs as a central improvement area in itself, helping to coordinate insights in all other improvement areas.



The role of infrastructuring in educational innovation

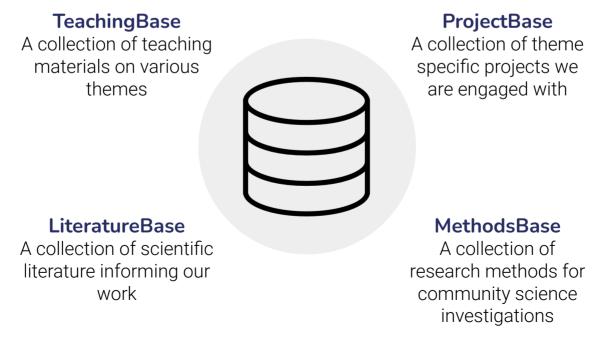
With our design concept, we put forth a vision of curriculum and pedagogy that puts reflection on what it means to be human in the center. This vision requires a reinterpretation of curriculum and reorganization of education systems. Such broader change of cultural systems takes *time* and *many people* that have a *shared vision*.

Long-term and networked educational systems improvement is supported by creating infrastructure (i.e. *infrastructuring*¹), or creating the tools, resources, processes, institutions, technologies, knowledge, and skills to drive effective design, implementation, evaluation, and improvement of innovations.

In this context, OpenEvo maintains a digital infrastructure to support the co-design, implementation, evaluation, sharing, and capacity building around our educational innovations.

OpenEvo Research Hub

Our website where we curate and make accessible various elements of our educational design work.



OpenEvo digital infrastructure

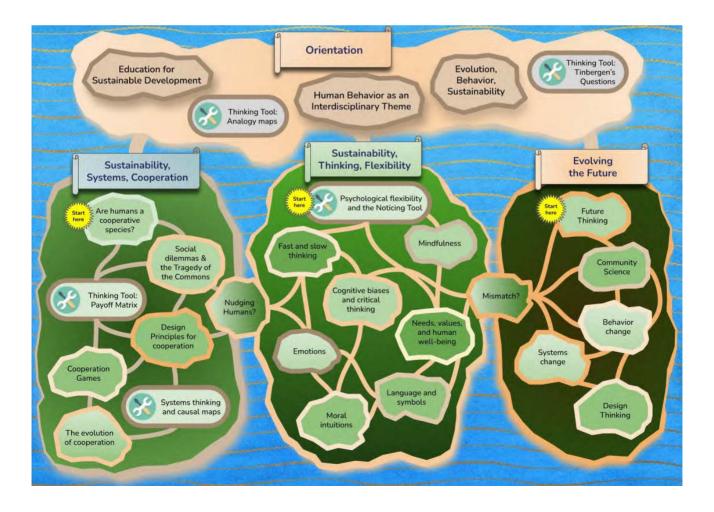
OpenEvo Learning Hub



A Moodle Learning Management System on which we and others can design and implement a diversity of units and modules related to the themes explored in this guide.

Human Behavior & Sustainable Development

An interdisciplinary pre-service teacher education module that introduces participants to our educational design concept and a diversity of themes in the behavioral sciences that are relevant to human well-being and sustainable development. Through a combination of self-directed online learning journeys, methods explorations, as well as application assignments, participants reflect and develop their own competencies and get to know a variety of ways to teach human behavior as an interdisciplinary theme in their future classrooms.



OpenEvo digital infrastructure

OpenEvo AI innovation



The rapid advancement of AI technologies and tools present great opportunities to interact with and use our educational design concept. It allows us to combine the strengths of AI in terms of access to vast amounts of human knowledge, with the strengths of our design concept in providing a particular structure for organizing this knowledge.

Educational Design Lab

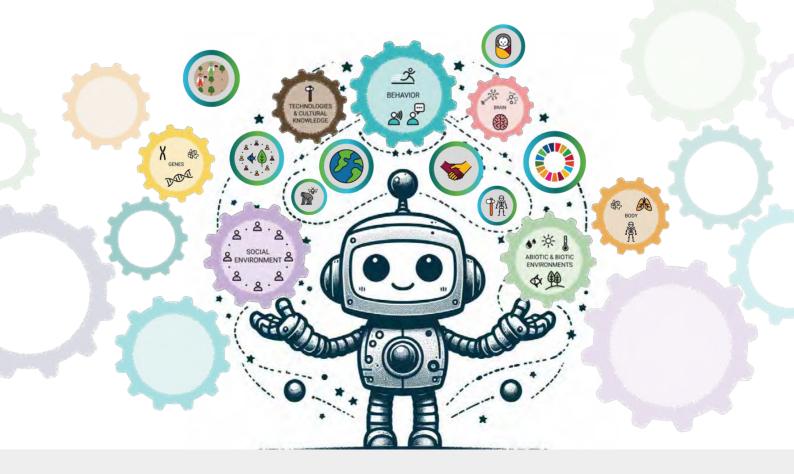
Supports for prompt engineering and workflows for curriculum and lesson design

Enabling critical use of AI to explore questions about human evolution, behavior, and sustainability

Community Science Labs

Supports for prompt engineering and workflows for community science methods and analysis

Supports for engaging communities in Al-related policy issues



Aked, J., Marks, N. A., Cordon, C., & Thompson, S. (2008). Five Ways to Well-being. New economics foundation. https://neweconomics.org/2008/10/five-ways-to-wellbeing

Ariew, A., & Panchanathan, K. (2023). Adding Agency to Tinbergen's Four Questions. In A. du Crest, M. Valković, A. Ariew, H. Desmond, P. Huneman, & T. Reydon (Eds.), Evolutionary Thinking Across Disciplines. Problems and Perspectives in Generalized Darwinism. Springer.

Atkins, P., Wilson, D.S., & Hayes, S.C. (2019). Prosocial: Using Evolutionary Science to Build Productive, Equitable, and Collaborative Groups. Context Press.

Basarkod, G. (2019). The six ways to well-being (6W-WeB): A new measure of valued action that targets the frequency and motivation for six behavioural patterns that promote well-being [Dissertation, Australian Catholic University]. https://www.basarkod.com/sixways

Bernstein, A., Hadash, Y., Lichtash, Y., Tanay, G., Shepherd, K., & Fresco, D. M. (2015). Decentering and Related Constructs: A Critical Review and Metacognitive Processes Model. Perspectives on Psychological Science : A Journal of the Association for Psychological Science, 10(5), 599–617. https://doi.org/10.1177/1745691615594577

Biglan, A., Zettle, R. D., Hayes, S. C., & Holmes, D. B. (2016). The Future of the Human Sciences and Society. In: R. D. Zettle, S. C. Hayes, D. Barnes-Holmes, & A. Biglan (Eds.), The Wiley Handbook of Contextual Behavioral Science (pp. 531–540). Wiley & Sons.

Binz, M., & Schulz, E. (2023). Using cognitive psychology to understand GPT-3. Proceedings of the National Academy of Sciences, 120(6), e2218523120. https://doi.org/10.1073/pnas.2218523120

Böhm, G., & Pfister, H. R. (2015). How people explain their own and others' behavior: A theory of lay causal explanations. Frontiers in Psychology, 6(FEB), 1–15. https://doi.org/10.3389/fpsyg.2015.00139

Brinkmann, L., Baumann, F., Bonnefon, J.-F., Derex, M., Müller, T. F., Nussberger, A.-M., Czaplicka, A., Acerbi, A., Griffiths, T. L., Henrich, J., Leibo, J. Z., McElreath, R., Oudeyer, P.-Y., Stray, J., & Rahwan, I. (2023). Machine culture. Nature Human Behaviour, 7(11), Article 11. https://doi.org/10.1038/s41562-023-01742-2

Brundtland, G.H. (1987) Our Common Future: Report of the World Commission on Environment and Development. Geneva, UN-Document A/42/427. http://www.un-documents.net/wced-ocf.htm

Burkart, J. M., Hrdy, S. B., & van Schaik, C. P. (2009). Cooperative Breeding and Human Cognitive Evolution. Evolutionary Anthropology, 18, 175–186. https://doi.org/10.1002/evan.20222

Chase, J. A., Houmanfar, R., Hayes, S. C., Ward, T. A., Vilardaga, J. P., & Follette, V. (2013). Values are not just goals: Online ACT-based values training adds to goal setting in improving undergraduate college student performance. Journal of Contextual Behavioral Science, 2(3–4), 79–84. https://doi.org/10.1016/j.jcbs.2013.08.002

Ciarrochi, J. & Hayes, L. (2018). Shaping DNA (Discoverer, Noticer, and Advisor): A Contextual Behavioral Science Approach to Youth Intervention. In: Wilson, D.S. & Hayes, S.C. Evolution and Contextual Behavioral Science (pp. 107-124). Context Press.

Cohen, G. L., Garcia, J., Apfel, N., & Master, A. (2006). Reducing the racial achievement gap: A social-psychological intervention. Science, 313(5791), 1307–1310. https://doi.org/10.1126/science.1128317

Cope, B., & Kalantzis, M. (2015). The things you do to know: An introduction to the pedagogy of multiliteracies. In A pedagogy of multiliteracies (pp. 1-36). Palgrave Macmillan.

Cope, B., & Kalantzis, M. (2020). Learning by Design - Pedagogy. https://newlearningonline.com/learning-by-design/pedagogy

Csibra, G., & Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. Philosophical Transactions of the Royal Society B: Biological Sciences, 366(1567), 1149–1157. https://doi.org/10.1098/rstb.2010.0319

Cultural Evolution Society (2023). What is cultural evolution. https://culturalevolutionsociety.org/story/What_is_Cultural_Evolution

DeLouize, A. M., Coolidge, F. L., & Wynn, T. (2017). Dopaminergic systems expansion and the advent of Homo erectus. Quaternary International, 427, 245–252. https://doi.org/10.1016/j.quaint.2015.10.123

Dobzhansky, T. (1973). Nothing in Biology Makes Sense except in the Light of Evolution. The American Biology Teacher, 35(3), 125-129. https://doi.org/10.2307/4444260

Dweck, C. S. (2006). Mindset: The New Psychology of Success. Random House Publishing Group.

Eirdosh, D., & Hanisch, S. (2023). A Community Science Model for Inter-disciplinary Evolution Education and School Improvement. In A. du Crest, M. Valković, A. Ariew, H. Desmond, P. Huneman, & T. A. C. Reydon (Eds.), Evolutionary Thinking Across Disciplines: Problems and Perspectives in Generalized Darwinism (pp. 125–146). Springer International Publishing. https://doi.org/10.1007/978-3-031-33358-3_7

Erickson, H. L., Lanning, L. A., & French, R. (2017). Concept-Based Curriculum and Instruction for the Thinking Classroom (2nd ed.). Corwin Press.

Frank, M. C. (2023a). Bridging the data gap between children and large language models. Trends in Cognitive Sciences, 27(11), 990–992. https://doi.org/10.1016/j.tics.2023.08.007

Frank, M. C. (2023b). Large language models as models of human cognition. https://doi.org/10.31234/osf.io/wxt69

Fuentes, A. (2014). It's Not All Sex and Violence: Agustin Fuentes at TEDxUND. https://www.youtube.com/watch?v=66leDfeGbzA

Gao, S., & Gao, A. K. (2023, July 19). On the Origin of LLMs: An Evolutionary Tree and Graph for 15,821 Large Language Models. arXiv.Org. https://arxiv.org/abs/2307.09793v1

Goldstone, R. L. & Wilensky, U. (2008). Promoting transfer by grounding complex systems principles. The Journal of the Learning Sciences, 17(4), 465–516. http://dx.doi.org/10.1080/10508400802394898

Gopnik, A., Meltzoff, A. N., & Kuhl, P. K. (2000). The scientist in the crib. HarperCollins.

Gray, P. (2011). The Evolutionary Biology of Education: How Our Hunter-Gatherer Educative Instincts Could Form the Basis for Education Today. Evolution: Education and Outreach, 4(1), 28–40. https://doi.org/10.1007/s12052-010-0306-1

Greene, J. D. (2013). Moral Tribes. Emotion, Reason and the Gap Between Us and Them. The Penguin Press.

Grinberg, R., Mehl, C., Sarrouf, J., & Isbell, D. (2018). OpenMind [™] Workshop Facilitator Guide. https://openmindplatform.org/wp-content/uploads/2018/12/OpenMind_Facilitator-Guide_12-12-18.pdf

Haidt, J. (2003). The Moral Emotions. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), Handbook of affective sciences (pp. 852–870). Oxford University Press.

Haidt, J. (2012). The Righteous Mind: Why Good People Are Divided by Politics and Religion. Pantheon Books.

Hanel, P. H. P., Roy, D., Taylor, S., Franjieh, M., Heffer, C., Tanesini, A., & Maio, G. R. (2023). Using self-affirmation to increase intellectual humility in debate. Royal Society Open Science, 10(2), 220958. https://doi.org/10.1098/rsos.220958

Hanisch, S., & Eirdosh, D. (2020). Causal Mapping as a Teaching Tool for Reflecting on Causation in Human Evolution. Science & Education. https://doi.org/10.1007/s11191-020-00157-z

Hanisch, S., & Eirdosh, D. (2021). Are Humans a Cooperative Species? Challenges & Opportunities for Teaching the Evolution of Human Prosociality. The American Biology Teacher, 83(6), 356–361. https://doi.org/10.1525/abt.2021.83.6.356

Hanisch, S., Eirdosh, D., Schäfer, M., & Haun, D. (2021). What Is "Fair" Is Not the Same Everywhere. Frontiers for Young Minds, 9. https://doi.org/10.3389/frym.2021.580435

Hanisch, S., & Eirdosh, D. (2022). Cooperation as a causal factor in human evolution: A scientific clarification and analysis of German high school biology textbooks textbooks. Journal of Biological Education. https://doi.org/10.1080/00219266.2021.2020875

Hanisch, S., & Eirdosh, D. (2023a). Behavioral Science and Education for Sustainable Development: Towards Metacognitive Competency. Sustainability, 15(9), 7413. https://doi.org/10.3390/su15097413

Hanisch, S., & Eirdosh, D. (2023b). Teaching for the Interdisciplinary Understanding of Evolutionary Concepts. In A. du Crest, M. Valković, A. Ariew, H. Desmond, P. Huneman, & T. A. C. Reydon (Eds.), Evolutionary Thinking Across Disciplines: Problems and Perspectives in Generalized Darwinism (pp. 147–180). Springer International Publishing. https://doi.org/10.1007/978-3-031-33358-3_8

Hanisch, S., Eirdosh, D., & Morgan, T. (2023). Evolving cooperation and sustainability for common pool resources. In X. Sá-Pinto, A. Beniermann, T. Børsen, M. Georgiou, A. Jeffries, P. Pessoa, B. Sousa, & D.L. Zeidler (Eds.), Learning evolution through socioscientific issues (pp. 127–147). UA Editora. http://doi.org/10.17617/2.3486776

Hardin, G. (1968). The Tragedy of the Commons. Science, 162(June), 1243–1248. https://doi.org/10.1126/science.162.3859.1243

Hayes, L. & Ciarrochi, J. (2015). The thriving adolescent. Using Acceptance and Commitment Therapy and Positive Psychology to Help Teens Manage Emotions, Achieve Goals, and Build Connections. Context Press.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? Behavioral and Brain Sciences, 33(2–3), 61–83; discussion 83-135. https://doi.org/10.1017/S0140525X0999152X

Herwix, A., Bogner, K., Schlaile, M. P., Friedrich, J., Zscheischler, J., & Avelino, F. (2023). Core Design Principles for Just Sustainability Transitions: A Framework for Organizing Just and Sustainable Collective Action. Presented at the 14th International Sustainability Transitions Conference, Utrecht, Netherlands.

Heyes, C. M. (2018). Cognitive Gadgets. The cultural evolution of thinking. Harvard University Press.

Heyes, C. M. (2020). Culture Primer. PsyArXiv. https://doi.org/10.31234/osf.io/v8ms3

Hildebrandt, L. K., McCall, C., & Singer, T. (2017). Differential Effects of Attention-, Compassion-, and Socio-Cognitively Based Mental Practices on Self-Reports of Mindfulness and Compassion. Mindfulness, 8(6), 1488–1512. https://doi.org/10.1007/s12671-017-0716-z

Hofstadter, D. R., & Sander, E. (2013). Surfaces and Essences: Analogy as the Fuel and Fire of Thinking (1st edition). Basic Books.

Högberg, A. & Gärdenfors, P. (2015). Children, Teaching and the Evolution of Humankind. Childhood in the Past, 8(2), 113–121. https://doi.org/10.1179/1758571615Z.0000000033

Hrdy, S. B. (2009). Mothers and Others: The Evolutionary Origins of Mutual Understanding. Harvard University Press.

Kahneman, D. (2011). Thinking, Fast and Slow. Farrar, Straus and Giroux.

Kashdan, T. B., & Rottenberg, J. (2010). Psychological Flexibility as a Fundamental Aspect of Health. Clin Psychol Rev., 30(7), 865–878. https://doi.org/10.1016/j.cpr.2010.03.001

Keltner, D. (2021). In: Empathy Lab. Interview with Pete Docter & Dacher Keltner. https://medium.com/google-empathy-lab/conversations-with-the-lab-pete-docter-dacher-keltner-5a9ecf5cb927

Kim, D. H. (2000). Systems Archetypes I. Diagnosing Systemic Issues and Designing High-Leverage Interventions. Pegasus Communications.

Koomen, R. & Herrmann, E. (2018a). Chimpanzees overcome the tragedy of the commons with dominance. Scientific Reports, 8(1), 10389. https://doi.org/10.1038/s41598-018-28416-8

Koomen, R. & Herrmann, E. (2018b). An investigation of children's strategies for overcoming the tragedy of the commons. Nature Human Behaviour, 2, 348–355. https://doi.org/10.1038/s41562-018-0327-2

Levitis, D. A., Lidicker, W. Z., & Freund, G. (2009). Behavioural biologists do not agree on what constitutes behaviour. Animal Behaviour, 78(1), 103–110. https://doi.org/10.1016/j.anbehav.2009.03.018

Li, N. P., van Vugt, M., & Colarelli, S. M. (2018). The Evolutionary Mismatch Hypothesis: Implications for Psychological Science. Current Directions in Psychological Science, 27(1), 38–44. https://doi.org/10.1177/0963721417731378

Lilienfeld, S. O., Ammirati, R., & Landfield, K. (2009). Giving Debiasing Away. Can Psychological Research on Correcting Cognitive Errors Promote Human Welfare? Perspectives on Psychological Science, 4(4), 390–398. https://doi.org/10.1111/j.1745-6924.2009.01144.x

Martinez, J. (2023). The Survival-Vital Matrix. https://www.theactmatrix.com/blog/trauma

McMahan, E. A., & Estes, D. (2011). Measuring Lay Conceptions of Well-Being: The Beliefs About Well-Being Scale. Journal of Happiness Studies, 12(2), 267–287. https://doi.org/10.1007/s10902-010-9194-x

Meadows, D., & Wright, D. (2008). Thinking in Systems. A Primer. Earthscan.

Mercier, H., & Sperber, D. (2011). Why do humans reason? Arguments for an argumentative theory. The Behavioral and Brain Sciences, 34(2), 57–74; discussion 74-111. https://doi.org/10.1017/S0140525X10000968

Messner, D., Guarín, A., & Haun, D. B. M. (2013). The Behavioural Dimensions of International Cooperation. Centre for Global Cooperation Research. http://dx.doi.org/10.2139/ssrn.2361423

Miyake, A., Kost-Smith, L., Finkelstein, N., Pollock, Cohen, G., & Ito, T. (2010). Reducing the Gender Achievement Gap in College Science: A Classroom Study of Values Affirmation. Science, 330(November), 1234–1237. https://doi.org/10.1126/science.1195996

Moallemi, E. A., Hosseini, S. H., Eker, S., Gao, L., Bertone, E., Szetey, K., & Bryan, B. A. (2022). Eight Archetypes of Sustainable Development Goal (SDG) Synergies and Trade-Offs. Earth's Future, 10(9), e2022EF002873. https://doi.org/10.1029/2022EF002873

Morgan, T. J. H., Uomini, N. T., Rendell, L. E., Chouinard-Thuly, L., Street, S. E., Lewis, H. M., Cross, C. P., Evans, C., Kearney, R., De La Torre, I., Whiten, A., & Laland, K. N. (2015). Experimental evidence for the co-evolution of hominin tool-making teaching and language. Nature Communications, 6, 6029. https://doi.org/10.1038/ncomms7029

Muthukrishna, M., & Henrich, J. (2016). Innovation in the Collective Brain. Philosophical Transactions of the Royal Society B: Biological Sciences, 371(1690), 20150192. https://doi.org/10.1098/rstb.2015.0192

Nettle, D., Frankenhuis, W. E., & Panchanathan, K. (2023). Biology, Society, or Choice: How Do Non-Experts Interpret Explanations of Behaviour? Open Mind, 7, 625–651. https://doi.org/10.1162/opmi_a_00098

OECD. (2019). OECD Future of Education and Skills 2030. OECD Learning Compass 2030. A Series of Concept Notes (p. 149). OECD.

https://www.oecd.org/education/2030-project/contact/OECD_Learning_Compass_2030_Concept_Note_Series.pdf

OECD. (2020). Curriculum Overload. A way forward. In Curriculum Overload. OECD. https://doi.org/10.1787/3081ceca-en

Ostrom, E. (1998). The need for civic education: A collective action perspective. Workshop in Political Theory and Policy Analysis, Department of Political Science, Indiana University.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science, 325(5939), 419–422. https://doi.org/10.1126/science.1172133

Penuel, W. R. (2019). Infrastructuring as a Practice of Design-Based Research for Supporting and Studying Equitable Implementation and Sustainability of Innovations. Journal of the Learning Sciences, 28(4–5), 659–677. https://doi.org/10.1080/10508406.2018.1552151

Peoples, S.M., Hardecker, S., Watts, J., Greenhill, S., Colleran, H., & Haun, D.B.M. (2017). The Transmission of Cultural Values via Games. Cultural Evolution Society Conference, Jena, Germany.

Polk, K. L., & Schoendorff, B. (2014). The ACT matrix: A new approach to building psychological flexibility across settings and populations (K. L. Polk & B. Schoendorff, Eds.). Context Press/New Harbinger Publications.

Porter, T., Baldwin, C. R., Warren, M. T., Murray, E. D., Cotton Bronk, K., Forgeard, M. J. C., Snow, N. E., & Jayawickreme, E. (2021). Clarifying the Content of Intellectual Humility: A Systematic Review and Integrative Framework. Journal of Personality Assessment, 1–13. https://doi.org/10.1080/00223891.2021.1975725

Rahwan, I., Cebrian, M., Obradovich, N., Bongard, J., Bonnefon, J.-F., ... Wellman, M. (2019). Machine behaviour. Nature, 568(7753), 477–486. https://doi.org/10.1038/s41586-019-1138-y

Redman, A., & Wiek, A. (2021). Competencies for Advancing Transformations Towards Sustainability. Frontiers in Education, 6. https://doi.org/10.3389/feduc.2021.785163

Richerson, P. J., & Boyd, R. T. (2005). Not by Genes Alone. How Culture Transformed Human Evolution. University of Chicago Press.

Rose, S. (2023). What Are Our Underlying Needs? https://steverosephd.com/what-are-our-underlying-needs/

Rosenbaum, D. A. (2014). It's a Jungle in There: How Competition and Cooperation in the Brain Shape the Mind. Oxford University Press.

Sapolsky, R. M. (2018). Behave. The Biology of Humans at Our Best and Worst. Vintage.

Schäfer, M., Haun, D. B. M., & Tomasello, M. (2015). Fair Is Not Fair Everywhere. Psychological Science, 26(8), 1252–1260. https://doi.org/10.1177/0956797615586188

Schimmelpfennig, R., & Muthukrishna, M. (2023). Cultural evolutionary behavioural science in public policy. Behavioural Public Policy, 1–31. https://doi.org/10.1017/bpp.2022.40

Schimmelpfennig, R., Razek, L., Schnell, E., & Muthukrishna, M. (2021). Paradox of diversity in the collective brain. Philosophical Transactions of the Royal Society B: Biological Sciences, 377(20200316). https://doi.org/10.1098/rstb.2020.0316

Schubert, C. (2016). Green nudges: Do they work? Are they ethical? (Joint Discussion Paper Series in Economics). Philipps-University Marburg, School of Business and Economics. http://hdl.handle.net/10419/129284

Schuppli, C., & van Schaik, C. P. (2019). Animal cultures: How we've only seen the tip of the iceberg. Evolutionary Human Sciences, 1, e2. https://doi.org/10.1017/ehs.2019.1

Schwartz, R. C., & Sweezy, M. (2019). Internal family systems therapy. Guilford Publications.

Seeley, T. D., Visscher, P. K., & Passino, K. M. (2006). Group decision making in honey bee swarms. American Scientist, 94(3), 220–229. https://www.jstor.org/stable/27858770

Seeley, T. D. (2010). Honeybee Democracy. Princeton University Press.

Seeley, T. D. (2015). "Bienen fallen nicht auf Hypes herein". Wie entscheidet der Schwarm, und was hat eine Königin zu bestimmen? Ein Gespräch mit dem Verhaltensbiologen Thomas D. Seeley. Zeit Online. https://www.zeit.de/2015/17/verhaltensbiologie-bienen-schwarm

Shiffrin, R., & Mitchell, M. (2023). Probing the psychology of AI models. Proceedings of the National Academy of Sciences, 120(10), e2300963120. https://doi.org/10.1073/pnas.2300963120

Skinner, B. F. (1953). Science and human behavior. Macmillan.

Smaldino, P. E. (2017). Models Are Stupid, and We Need More of Them. In R. R. Vallacher, S. J. Read, & A. Nowak (Eds.), Computational Social Psychology (1st ed., pp. 311–331). Routledge. https://doi.org/10.4324/9781315173726-14

Stern, J., Ferraro, K., Duncan, K., & Aleo, T. (2021). Learning That Transfers: Designing Curriculum for a Changing World. Corwin.

Stern, J., Ferraro, K., & Mohnkern, J. (2017). Tools for Teaching Conceptual Understanding, Secondary. Designing Lessons and Assessments for Deep Learning. Corwin Press.

Suddendorf, T. (2006). Foresight and Evolution of the Human Mind. Science, 312, 1006–1007. https://doi.org/10.1126/science.1129217

Suddendorf, T. & Corballis, M.C. (1997). Mental time travel and the evolution of the human mind. Genet. Soc. Gen. Psychol. Monogr. 123, 133–167. http://www.ncbi.nlm.nih.gov/pubmed/9204544

Tenenbaum, J. B., Kemp, C., Griffiths, T. L., & Goodman, N. D. (2011). How to Grow a Mind: Statistics, Structure, and Abstraction. Science, 331(6022), 1279–1285. https://doi.org/10.1126/science.1192788

Thaler, R. H., & Sunstein, C. R. (2008). Nudge: Improving Decisions About Health, Wealth, and Happiness. Yale University Press.

Tinbergen, N. (1963). On aims and methods of Ethology. Zeitschrift Für Tierpsychologie, 20(4), 410–433. https://doi.org/10.1111/j.1439-0310.1963.tb01161.x

Tomasello, M. (2009). Why we cooperate. MIT Press.

Tomasello, M. (2014). What makes us human? https://www.youtube.com/watch?v=9vul34zyjqU&t=

Turchin, P. (2006). War and Peace and War. The rise and fall of empires. The Penguin Press.

Turchin, P. & Gavrilets, S. (2009). Evolution of Complex Hierarchical Societies. Social Evolution & History, 8(2), 167–198.

UNESCO (2017). Education for Sustainable Development Goals: Learning Objectives. https://unesdoc.unesco.org/ark:/48223/pf0000247444.locale=en

UNESCO. (2020). Education for sustainable development: A roadmap. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000374802

van Prooijen, J.-W., & van Vugt, M. (2018). Conspiracy Theories: Evolved Functions and Psychological Mechanisms. Perspectives on Psychological Science, 13(6), 770–788. https://doi.org/10.1177/1745691618774270

van Schaik, C. P., Pradhan, G. R., & Tennie, C. (2019). Teaching and curiosity: Sequential drivers of cumulative cultural evolution in the hominin lineage. Behavioral Ecology and Sociobiology, 73(1), 2. https://doi.org/10.1007/s00265-018-2610-7

Vansteenkiste, M., Ryan, R. M., & Soenens, B. (2020). Basic psychological need theory: Advancements, critical themes, and future directions. Motivation and Emotion, 44(1), 1–31. https://doi.org/10.1007/s11031-019-09818-1

Waring, T. M., Kline, M. A., Brooks, J. S., Goff, S. H., Gowdy, J., Janssen, M. A., ... Jacquet, J. (2015). A multilevel evolutionary framework for sustainability analysis. Ecology and Society, 20(2), art34. https://doi.org/10.5751/ES-07634-200234

Warneken, F. & Tomasello, M. (2009). Varieties of altruism in children and chimpanzees. Trends in Cognitive Sciences, 13(9), 397–402. https://doi.org/10.1016/j.tics.2009.06.008

Watson, R. A., & Szathmáry, E. (2016). How Can Evolution Learn? Trends in Ecology and Evolution, 31(2), 147–157. https://doi.org/10.1016/j.tree.2015.11.009

Whiten, A., & van Schaik, C. P. (2007). The evolution of animal "cultures" and social intelligence. Philosophical Transactions of the Royal Society B-Biological Sciences, 362(1480), 603–620. https://doi.org/10.1098/rstb.2006.1998

WHO (1994). Life skills education for children and adolescents in schools. Introduction and guidelines to facilitate the development and implementation of life skills programmes. 2nd rev. World Health Organization. https://apps.who.int/iris/handle/10665/63552

Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/ . Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL, USA.

Wilensky, U., & Papert, S. (2010). Restructurations: Reformulating Knowledge Disciplines through New Representational Forms. Constructionism 2010 : Constructionist Approaches to Creative Learning, Thinking and Education: Lessons for the 21st Century. Constructionism 2010 The 12th EuroLogo conference, Paris.

Willingham, D. T. (2008). Critical Thinking: Why Is It So Hard to Teach? Arts Education Policy Review, 109(4), 21–32. https://doi.org/10.3200/AEPR.109.4.21-32

Wilson, D. S., Ostrom, E., & Cox, M. E. (2013). Generalizing the core design principles for the efficacy of groups. Journal of Economic Behavior and Organization, 90, S21–S32. http://dx.doi.org/10.1016/j.jebo.2012.12.010

Wilson, K. G., Sandoz, E. K., Kitchens, J., & Roberts, M. (2010). The valued living questionnaire: Defining and measuring valued action within a behavioral framework. Psychological Record, 60(2), 249–272. https://doi.org/10.1007/BF03395706

Wood, W., Quinn, J. M., & Kashy, D. A. (2002). Habits in everyday life: Thought, emotion, and action. Journal of Personality and Social Psychology, 83(6), 1281–1297. https://doi.org/10.1037/0022-3514.83.6.1281

Yang, J., Jin, H., Tang, R., Han, X., Feng, Q., Jiang, H., Yin, B., & Hu, X. (2023, April 26). Harnessing the Power of LLMs in Practice: A Survey on ChatGPT and Beyond. arXiv.Org. https://arxiv.org/abs/2304.13712v2

Zimmerman, E. & Radespiel, E. (2007). Primate Life Histories. In: Henke, W., Tattersall, I., & Hardt, T. Handbook of Paleoanthropology (pp. 1163-1205). Springer.

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https://commons.wikimedia.org/wiki/File:Homo_heidelbergensis._Museo_de_Prehistoria_de_Valencia.jpg, CC BY-SA 4.0; H. habilis: Don Hitchcock, https://commons.wikimedia.org/wiki/File:KNM-ER_1813_skull.jpg, CC BY-SA 4.0; H. rudolfensis: LoKiLeCh, https://commons.wikimedia.org/wiki/File:Berlin_Naturkundemuseum_Homo_Rudolfensis_Schaedel.jpg, CC BY 3.0; H. erectus: Einsamer Schütze, https://commons.wikimedia.org/wiki/File:Smac_Pal%C3%A40ithikum_017.jpg, CC BY-SA 4.0; A. sediba: Lee R. Berger, https://commons.wikimedia.org/wiki/File:Australopithecus_Sediba_-_Transparent_Background.png, CC BY-SA 4.0; A. afarensis: Rama,

https://commons.wikimedia.org/wiki/File:Australopithecus_afarensis-MGL_95215-P5030041-white.jpg, CC BY-SA 3.0 FR; P. boisei: Rama, https://commons.wikimedia.org/wiki/File:Paranthropus_boisei_IMG_2933-white.jpg, CC BY-SA 3.0 FR; P. aethiopicus: 宜蘭第一公民, https://commons.wikimedia.org/wiki/File:Paranthropus_aethiopicus-white_background.jpg, CC BY-SA 4.0; A. ramidus: Rama, https://commons.wikimedia.org/wiki/File:Ardipithecus_Ramidus-MGL_96730-P5030040-white.jpg, CC BY 3.0; S. tchadensis: Rama,

https://commons.wikimedia.org/wiki/File:Sahelenthropus_tchadensis-MGL_95214-P4150633-white.jpg, CC BY 3.0; Xiahe mandible: Dongju Zhang, https://commons.wikimedia.org/wiki/File:Xiahe_mandible.jpg, CC BY-SA 4.0; H. naledi foot: W. E. H. Harcourt-Smith et al. (2015) https://doi.org/10.1038/ncomms9432, https://commons.wikimedia.org/wiki/File:Homo_naledi_foot-_adult_right.jpg, CC BY-SA 4.0;

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