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TEN STEPS TOWARDS SYSTEMS THINKING

An Education for Sustainable Development manual for teachers, educators, and facilitators

Thomas Hoffmann, Sanskriti Menon, Wendy Morel,
Thamsanqa Nkosi, Nicola Pape

ESD EXPERT NET

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By
Thomas Hoffmann, Sanskriti Menon, Wendy Morel,
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With Guidance on Systems Thinking by Kalyan Tanksale
and
Illustrations by Anusha Menon

Centre for Environment Education, India
February 2022

Online version of this resource is available at https://www.ceeindia.org/systemsthinking/

2022

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Website version: Infilon Technologies Pvt. Ltd.

ISBN: 978-93-84233-84-6

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The development and production of this publication and the accompanying website has been financially supported by ENGAGEMENT GLOBAL gGmbH, Bonn, Germany.

With funding from the

Federal Ministry
for Economic Cooperation
and Development

Suggested citation
Hoffmann T., Menon S., Morel W., Nkosi T., Pape N. (2022). *Ten Steps towards Systems Thinking: An Education for Sustainable Development Manual for teachers, educators, and facilitators.* Centre for Environment Education, India.

ACKNOWLEDGEMENTS

We thank ENGAGEMENT GLOBAL gGmbH for providing the financial support for producing this resource. We also thank our colleagues at the ESD Expert Net and Centre for Environment Education for their thoughtful suggestions for the content. We especially thank Kalyan Tanksale who reviewed the draft text and joined our discussions over several weeks with guidance on the systems concepts. We also thank Keiko Takahashi, Pukhraj Choudhary, Rajeswari Namagiri and Waheeda Carvello who patiently reviewed the text and made valuable suggestions for improvement. This resource has come alive and become user-friendly with the attractive layout by Ashok Thorave and illustrations by Anusha Menon, and we thank them for their creativity. We gratefully acknowledge all these inputs we have received but take responsibility for errors that may have remained.

Though this resource was conceptualized several years ago, we started working on an outline in 2018. Serious work was done almost entirely during the Covid-19 pandemic. Our families have always supported us, and we thank them for their forbearance and tolerance of our long weekly calls as we worked from home.

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Thomas lives in Baden-Württemberg, the southwestern state of Germany, and works as Head of Geography Department at the Teacher Training Center Karlsruhe, where he trains pre-service geography teachers for secondary schools (Gymnasium). Beside this, he is Honorary Professor for Education for Sustainable Development at Leuphana University in Lüneburg as well as Lecturer for Geography Didactics at Karlsruhe Institute for Technology (KIT). Thomas also teaches geography, history, political sciences, and economy at Windeck-Gymnasium in Bühl next to the Black Forest. With his interest in global challenges for several decades, he started to deal with ideas of education for sustainable development and global learning right from the beginning of the discussion in the 1990s. He has introduced these ideas into numerous geo-didactic articles as well as geography textbooks. Thomas is one of the founding members of the ESD Expert Net, an intercultural think tank on ESD, in which he heads the working group on the development of learning and teaching material.

Dr. Sanskriti Menon

Sanskriti is Senior Programme Director, Centre for Environment Education, and is based in Pune, India. She anchors CEE's Urban Programmes and is involved in a range of urban issues including mobility, waste, ecosystems, and climate change. She is particularly interested in Education for Sustainable Development, and collaborative governance systems to address sustainability issues. Sanskriti comes to Systems Thinking with the hope of being able to facilitate multi-stakeholder processes that enhance systems understanding and collaborative action for sustainability. Sanskriti is a member of the ESD Expert Net and of the Board of Directors of the Foundation for Environmental Education (FEE).

Wendy Morel

Wendy has worked in formal education in natural sciences in Mexico for more than 20 years. Currently based between Mexico City and Berlin, she is carrying out her doctoral research at the Humboldt Universität zu Berlin in the field of Education for Sustainable Development. In the last ten years, she has developed and facilitated programmes and international teachers training in ESD. As a member of the ESD Expert Net she has participated in the development of teaching and learning material. Wendy facilitates virtual exchanges related to the 17 Sustainable Development Goals between schools from Germany, Mexico, India, and South Africa through the Go! Global program. Her interest in Systems Thinking competencies arises from the need for quality education that enables and empowers the learners and teachers to become change-makers, along with the demand for material and support for teachers training.

Thamsanqa lives in Pretoria, South Africa and is the Principal of a Secondary School in Emalahleni, Witbank. He has been working for the Department of Basic Education as a science teacher for years now. Thami, as he is affectionately known, has worked on the topic of SDGs on different projects. He is the co-founder of the Go! Global programme and has facilitated several virtual exchanges on the subject. He met up with his co-authors in the ESD Expert Net that has been in existence for years now and through this collaborative work has shared the passion for exploring and developing this material. Thami believes that enhancing our own and our learners' systems thinking competence is the path towards a sustainable future.

Thamsanqa Nkosi

Nicola Pape

Nicola lives in Bonn, Germany since her return to Germany from a two-year long stay in Harare, Zimbabwe. She has been working for GIZ as project leader on international capacity building in the field of quality education. Since 2012 she has been a project coordinator at ENGAGEMENT GLOBAL gGmbH in the ESD Expert Net programme. As a student of sociology and anthropology at the University of Bielefeld she had a chance to accompany the famous sociologist Niklas Luhmann during the world conference of sociologists hosted at the University of Bielefeld. Her passion is to develop and implement programmes on quality education and education for sustainable development. Over the last few years, she has focused her work on the development of teaching materials for trainers and teachers in the field of Education for Sustainable Development together with the ESD Expert Net.

CONTRIBUTORS

Guidance on Systems Thinking

Kalyan Tanksale seeks to apply systems thinking, facilitate action learning and catalyze collaborations for impactful, scalable, and sustainable change. He has worked with governments, philanthropic organizations, academic and research institutions, civil society organizations and tribal, rural, and urban communities with systems approaches reaching the lives of nearly 5 million people. Kalyan is currently managing a Tribal Livelihoods program at SWISSAID in India. He is an alumnus of Institute of Development Studies (IDS), University of Sussex, IIT Bombay, and University of Bergen in Norway.

Kalyan Tanksale

Illustrations

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Anusha Menon is an award-winning independent illustrator and animator who has illustrated storybooks for children, nature guides, and nature posters. She loves animating music videos and plays the drums and the bass guitar to keep a sense of rhythm in life and work. A graduate of the National Institute of Design, Anusha is interested in visual design to communicate sustainability concepts.

FOREWORD

Anita Reddy
Head of Division for Education Programmes
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Learning for a better future –This slogan highlights the imperative of constant evolution of teaching and learning approaches as our actions today impact a complex web of developments in the future. In recent decades and in the present time, new approaches must be developed to address the challenges of our times. A focus on sustainable development is essential to ensure a healthy and liveable planet, which is why the achievement of the 17 Sustainable Development Goals (SDGs) and the implementation of the Agenda 2030 are essential.

Through successfully converting the concept of sustainability into a central narrative in more and more spheres of society in several countries, "Education for Sustainable Development" (ESD) has gained broader attention and importance. ESD is defined as an explicit field of action in SDG 4.7 and refers to the implementation of an educational practise that aims to ensure that everyone has the opportunity to contribute to a sustainable future through certain knowledge and competencies. To achieve a positive impact, UNESCO (2017) identified eight key competencies of ESD, which each of us should master to be truly able to contribute to change. One of these is the systems thinking competency.

The complexity and interconnectedness of the issues related to global sustainable development require the adoption and inculcation of this competence. It can be understood as "the abilities to recognise and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty" (UNESCO 2017, p.10).

But how can teachers be supported in adopting systems thinking approaches as a key element of ESD? How can global challenges such as climate change or health and economic crisisbe enlaced with local issues regarding the school itself? And how can teachers motivate students to actively participate in the implementation of solution strategies? Since a holistic and future-oriented approach is central to ESD, it is important to start not only in single subjects within school education but also to learn how to transform the learning environment in and around schools. To date, there are only a few publications that explicitly apply the approach of systems thinking to the teaching of Education for Sustainable Development. For this reason, this manual provides teachers with didactic-methodological strategies for transmitting and strengthening competencies for dealing with complexity.

We would like to invite you to walk the branching paths of systems thinking with your students. This manual can be understood as a trekking map of this path, which must be explored step by step. Therefore, it contains a theoretical guideline of ten steps (competencies) that build on each other and are accompanied by two illustrative examples. These, as well as the tools from the pool of methods provided, can be adapted and adopted in your individual teaching context.

Finally, we would like to express our sincere gratitude to the authors of the ESD Expert Net for creating this comprehensive teaching resource.

Yours
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FOREWORD

Kartikeya V. Sarabhai
Director, Centre for Environment Education

Humans have for long thought that their individual actions were surely too small to affect the larger systems that make our planet work. Before the Industrial Revolution, that statement would have been largely true. But over the last two centuries, things have changed dramatically. Our ability to extract fossil fuels and use them to fuel machines, vehicles, factories and human habitats, our advances in medicines including the fight against bacteria and viruses, the rapid transformation in the modes of mobility, and in general, the changes in lifestyles as we have become more prosperous, have all led to our becoming the first species on this planet that actually threatens the balance that has made life possible.

Even as science advanced and our understanding of natural phenomena grew, knowledge remained largely within the classical disciplines. However, as the discipline of ecology emerged, it started to examine interconnections. In the initial stages, connections were rarely made between the activities of people and the impacts they were having on our environment. But as environmental changes started to become evident, long connections were made. In the early 1960s, Rachael Carson's book Silent Spring connected the absence of birds with the use of pesticides. Species loss and pollution were among the early warning signs. Today, whether it is the loss of biodiversity, the pollution of the oceans and air or climate change, we know how intricately these are connected with human lifestyles and our growing footprints. Yet, the Covid-19 pandemic has also shown how vulnerable even our powerful speciesis. Increasingly, we realize how interconnected we are to the environment, locally and globally.

But while Science has changed and understands the need to study phenomena in their larger context, human thinking and its view of development has remained largely linear. It is only more recently that people are emphasizing circular models. One of the reasons for this is perhaps that our educational system has been slower to respond. Subjects are still taught in silos. This is why environmental education and education for sustainable development become so critical. Studying environmental issues give the student one of the best opportunities to integrate knowledge acquired in various disciplines. In their book, *The Systems View of Life,* Fritj of Capra and Pier Luigi Luisi write "In the coming decades, the survival of humanity will depend on our ecological literacy – our ability to understand the basic principles of ecology and to live accordingly. This means that eco-literacy must become a critical skill for politicians, business leaders, and professionals in all spheres, and should be the most important part of education at all levels – from primary and secondary schools to colleges, universities, and the continuing education and training of professionals."

Such an education emphasizes relationships, patterns and context. One starts understanding systems. This volume, meant for teachers, gives practical ways in which system thinking can be introduced into formal educational programmes as well as in non-formal workshops with youth and community groups. We hope it will help take learners a few steps closer to understanding how we are interconnected and how we can move to more sustainable lifestyles.

Kartikeya V. Sarabhai
Director, Centre for Environment Education

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INTRODUCTION

Why the need for Systems Thinking Competence?

We are part of systems - the world shapes us, and we shape the world

When we have a cup of tea, coffee, or milk; when we get dressed, and when we walk, cycle, drive a car, take a bus to get to a desk, or fieldwork – whatever be our actions, local and global contexts constantly influence our lives. In turn, our behaviour, choices, preferences for different goods and services shape the global context. These intricate connections are the reality for each of us – wherever we are and whether we realize it or not.

The connections exist because the production, trade, movement of goods and products through the supply chain, and consumption of the goods and services we use in our daily lives for our basic needs, wants and well-being are dependent on natural resources such as water, soil, and raw materials.

There are various ways of using natural resources for achieving human well-being. Some production and consumption systems are less resource intensive. Others are a lot more, and lead to severe stress on the environment, as well as on human society.

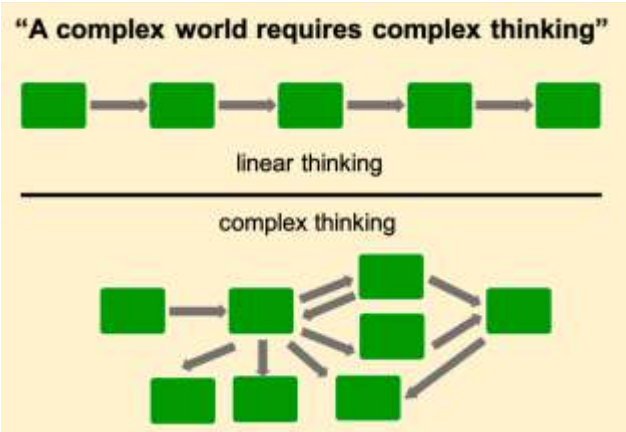
Pollution, water scarcity, soil degradation, loss of biodiversity, and climate change are crucial indicators of the stress on natural resources while poverty, hunger, and displacement reflect the negative impact on human society. These continue to increase with the global population and corresponding consumption levels.

Degradation of natural habitats has different types of impacts on human beings. These may include diminished productivity of farms, reduced access to nutritious food, livelihoods, and income. They may also occur due to the arrangements made (or not made) among people (communities, states, countries), which may lead to conflicts of different kinds. In extreme circumstances conflicts may result in wars and violation of human rights.

Human beings also have the ability to avoid environmental degradation and pollution due to human actions. Systems approaches can help.
We observe around us a multitude of natural and societal processes like physical settings, landscapes, objects that are both natural and human-made. They include people, their activities, values, cultural practices, and traditional and modern ideas, and rules that govern their lives.

The processes are interconnected in a complex web and influence each other. Some processes and connections form subgroups within larger webs with denser interconnections. These complex and dynamic interconnections occur not only at the global but also at the local scale. Interconnections link to individual elements, such as a person or a tree or an individual shop.

The challenges we face are not quite simple linear cause and effect sequences. Multiple factors in a given challenge interact in different ways, with reinforcing and/or balancing feedback loops.



A reinforcing loop is a situation in which an action produces a result which influences more of the same action thus resulting in growth or decline. For example, in a savings bank account, the principal amount attracts an interest, and that amount is added to the principal using the interest rate. The principal plus the amount added as the interest becomes the new increased principal amount for the next time the interest amount is calculated. In the context of climate change, ice sheets on oceans reflect sunlight reducing the heat absorbed by the earth. However,

global warming melts the ice, and the dark ocean is exposed which absorbs more heat. Without the insulating sheet of ice, the ocean also releases more heat into the atmosphere which further adds to global warming.

A balancing loop on the other hand works towards reaching a set point and maintaining the system at that point. For example, the thermostat in an air conditioner or a heating unit tries to maintain the temperature of the room.

Both balancing and reinforcing loops are present in the systems we are part of. The reinforcing or balancing effect may or may not be seen immediately. The presence of multiple types of feedback may result in unpredictable situations – sometimes taking us by surprise, or manifest as unintended consequences, or even occur as a completely new form of the system.

Therefore, linear thinking is not enough to deal with complexity because it deals with simple cause and effect, or sequential events.

Changes may occur constantly or intermittently, and in the same location or in another location, depending on the system. Consequences may become evident immediately or after several years or even decades after the changes are set in motion. Climate Change is one such example, with impacts that are evident across different time scales, and regions, and with varying intensity.

All the individual objects and processes on the earth are part of an interconnected whole, which we may call the "Earth System". However, each of these different elements may be part of multiple subsystems at the same time, nested under larger systems. For example,

- The weather system is a part of the climate system. The rain and trees that form part of the weather system of a particular region are part of the local ecosystem.
- Individual classes are a part of the school, and the school is a part of the city it is in, but the school is also part of the education system of the state or province, or country.
- A house may be part of a neighbourhood, village or town, while people living in that house may be part of a countrywide community of stamp collectors or amateur radio enthusiasts.

Considering the possibility of interconnections of global-scale processes and the varying time scales of changes in the world, we human beings must develop the methods and skills to understand and work with such complexity. Hence there is a need for developing systems thinking competence.

'Systems thinking' is principally a solution-oriented analytical approach. The problems we face may be investigated through a systems exploration. It can lead to a deeper understanding of issues and help reveal the root causes.

Education for Sustainable Development

In response to the emergence and recognition of global challenges, educators from all over the world continue to develop learning approaches, such as global citizenship education, transformative learning, etc. These approaches are an integral part of Education for Sustainable Development (ESD). ESD seeks to ensure the contribution of education to a cross-societal transformation towards a sustainable world.

According to UNESCO (2016), "Education for Sustainable Development: empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy, and the learning environment. It achieves its purpose by transforming society."

A discussion on perspectives about ESD

There are different perspectives about sustainability, sustainable development and ESD. For a discussion on these aspects and views, see the article *What is Education for Sustainable Development?* by Thomas Hoffmann and Hannes Siege, available online at the link https://www.ceeindia.org/systemsthinking/resources/ .

ESD is part of the Sustainable Development Goals (SDGs)

The SDGs deal with the most significant challenges of our world and were adopted by all United Nations Member States in September 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. ESD is also integrated within the SDGs.

They include some of the intractable and oldest challenges like poverty and inequality.

SDG 4 on 'Quality Education' is the door for educators to contribute to these internationally agreed goals. Targets are defined for each SDG. In the case of SDG 4, the target relevant for ESD is SDG 4.7.

Goal 4
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Target 4.7
All learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development.

Box 1 – the UN Sustainable Development Goals

Goal 1
End poverty in all its forms everywhere.

Goal 2
End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Goal 3
Ensure healthy lives and promote well-being for all at all ages.

Goal 4
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Goal 5
Achieve gender equality and empower all women and girls.

Goal 6
Ensure availability and sustainable management of water and sanitation for all.

Goal 7
Ensure access to affordable, reliable, sustainable and modern energy for all.

Goal 8
Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Goal 9
Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Goal 10
Reduce inequality within and among countries.

Goal 11
Make cities and human settlements inclusive, safe, resilient and sustainable.

Goal 12
Ensure sustainable consumption and production patterns.

Goal 13
Take urgent action to combat climate change and its impacts.

Goal 14
Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Goal 15
Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Goal 16
Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

Goal 17
Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Enhancing Systems Thinking competence as part of ESD

It is generally agreed that people 'need to have certain key competences that allow them to engage constructively and responsibly with today's world' (UNESCO, 2017).

Competences are specific attributes that individuals need for action and self-organization in various complex contexts and situations. They include cognitive, affective, volitional, and motivational elements. Hence, they are an interplay of knowledge, capacities and skills, motives, and affective dispositions. The different competences cannot be taught but have to be developed by the learners themselves. They are acquired during action, on the basis of experience and reflection (UNESCO, 2015; Weinert, 2001).

UNESCO identifies the following as the key competences to advance sustainable development (UNESCO, 2017, pg 10):

- Systems thinking competency: the ability to recognize and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and scales; and to deal with uncertainty.
- Anticipatory competency: the ability to understand and evaluate multiple futures – possible, probable, and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.
- Normative competency: the ability to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions.
- Strategic competency: the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield.
- Collaboration competency: the ability to learn from others; to understand and respect the needs, perspectives, and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving.
- Critical thinking competency: the ability to question norms, practices, and opinions; to reflect on one's own values, perceptions and actions; and to take a position in the sustainability discourse.
- Self-awareness competency: the ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.
- Integrated problem-solving competency: the overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive and equitable solution options that promote sustainable development, integrating the above-mentioned competences.

In this publication, we focus on the first, i.e.'Systems thinking competence', as it is in our view, a core competence.

"Competence" or "Competency"

Both forms are acceptable. In this book, we use "competence", except in the section above. In the publication referred to, "competency" has been used. We have retained this form in the material quoted from UNESCO, (2017).

What is "Systems Thinking" Competence?

In this manual, we describe Systems Thinking Competence as follows,

Systems thinking is the ability to describe and/or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not. (Based on Frischknecht-Tobler, U., Nagel U., Seyboldt, H., (2008)).

In order to make it clearer for learning practice:

Systems thinking competence is the:

- ability to describe and/or visualise a part of a complex reality,
- express that part of reality as a model,
- understand the model as a system,
- use the model to explain the behaviour of the system,
- anticipate the behaviour of the system,
- evaluate its impacts on sustainable development,
- identify potential points of intervention,
- identify types of interventions,
- generate options to act,
- assess the impacts of the interventions in the frame of sustainable development and decide whether further actions are necessary or not.

In this manual, each of these components of the definition is detailed out as a step with suggested activities and learning methods and two examples.

Why this manual?

While we recognize systems thinking as a core competence, as we also realize that it is not yet sufficiently addressed in school curricula and teacher education. With this manual we hope to provide a practice-oriented learning resource that helps learners of the age of 15 years and older (secondary education level) to develop systems thinking competence. The reason we suggest this age-group is that the cognitive abilities and ability for abstract thinking are likely to have developed to deal with complexity and systems thinking.

We have designed this Systems Thinking resource to also help develop other key competences, as described by UNESCO, to different degrees: anticipatory competence, normative competence, strategic competence, collaboration competence, critical thinking competence, self-awareness competence, and integrated problem-solving competence.

In the subsequent sections, we indicate through illustrations the competences likely to be strengthened in the learning processes presented. This manual is not designed as a standalone resource, but one that draws upon the concepts articulated in the global discourse on ESD, and which offers practical steps to develop systems thinking. In this context, the educator, whether a teacher or a community or youth group facilitator, has a key role in bringing the concepts of ESD into practice.

Ten Steps towards Systems Thinking

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

	Steps		Dimensions
From recognizing to modelling	**Step 1:**	Recognize a complex part of reality	Recognizing
	Step 2:	Express that part of reality as a model	
	Step 3:	Understand the model as a system	
Working with a model of a system to understand the future	**Step 4:**	Use the model to explain the behaviour of the system	Assessing
	Step 5:	Anticipate the behaviour of the system	
	Step 6:	Evaluate the current and potential results of the system behaviour in the frame of sustainable development	
Working with a model to influence the future	**Step 7:**	Identify potential points of intervention in the system	
	Step 8:	Identify potential types of intervention in the system	
	Step 9:	Generate outlooks and options to act for sustainable development	Acting
	Step 10:	Assess impacts of actions in the frame of sustainable development and decide whether further actions are necessary or not.	Assessing

How to use this book?

The "Ten Steps towards Systems Thinking" are arranged along the dimensions Recognizing, Evaluating, and Acting (UNESCO, 2017, p. 91). The steps begin with simple description of reality (recognizing), leading to progressive, comprehensive and deeper analytic understanding (evaluating), and therefore preparation to act more strategically (acting).

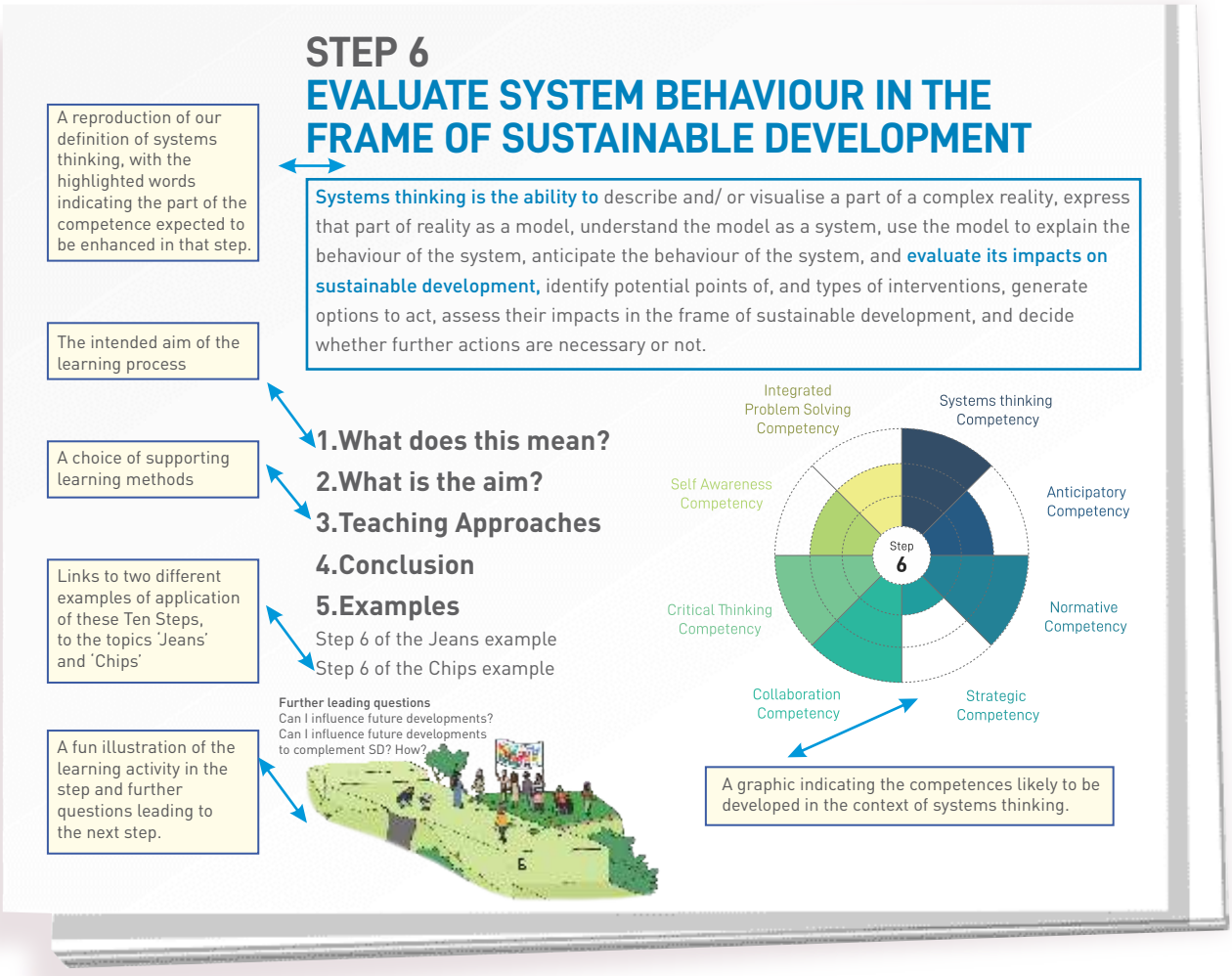
Theory through the Steps

Educators, teachers, community or youth facilitators contribute in different ways to develop systems thinking among learners, though the practice is not widespread. One reason is that most school curricula as well as teacher education programs do not offer a structured approach to developing systems thinking competence. We recommend this manual as a practical learning-teaching-learning resource to bridge this gap.

The next sections present a step-by-step guide to exploring and learning about systems.

Structure of the Steps

The ten steps are based on the definition already introduced in the section "What is "Systems Thinking" Competence?". Each of these steps is described as a chapter in the following sections.



Step-by-step learning

We invite users to imagine The Ten Steps like an ancient staircase, with steps of different heights and lengths, leading to a higher level. While climbing, while one foot is reaching the next step, the other foot rests behind. Each step enhances systems understanding, building upon the previous step and leading on to the next.

Note that you (and your learners or participants) don't have to scale all the ten steps at one go. It is possible to develop one's systems thinking competence by taking a few steps at a time.

Try and try again

Your learners may climb one step easily but find another a little challenging. They might start to climb but not manage to complete a step and have to make another attempt. We would like to encourage you, and in turn ask you to encourage your learners to recognize that developing a sound understanding of a topic from a systems perspective may require repeated reviews of what one knows and to look for new unexplored dimensions. The ability to review and consciously revise one's understanding is an important part of systems thinking.

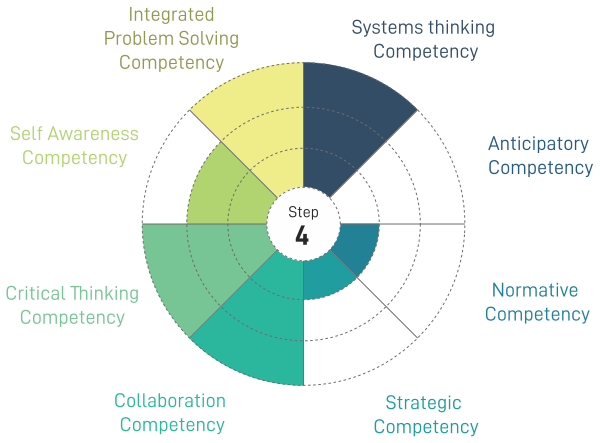
Activities, Learning Methods, Worksheets and Information Sheets

In each step, certain activities and tasks are suggested which use different learning methods. You can find all the learning methods in alphabetical order in the section on Learning Methods. Some steps also refer to Worksheets or Information Sheets. You can also find these in the latter section of this book. We suggest these learning methods and materials as supports to help the climbers on their journey. In a group of climbers, one may lend a helping hand to another. Therefore the learning process foresees the contribution of different ideas and abilities by participants.

At the end of each step, a few 'further leading questions' are suggested, which help in guiding the participants' thinking to the next step.

Supporting enhancement of the Sustainable Development competences

The Sustainable Development competences likely to be enhanced in each step are indicated using a radar chart such as the one presented below.



We have included such a graphic for each of the Ten Steps. They show the type of sustainable development (SD) competences that might be developed in the individual steps. Do note that these are only indicative of a low, medium, or strong possibility of competence enhancement, and not definitive representations.

We want to provide a hint to the facilitator that the indicated competences may be enhanced. Note that the opportunity and strengthening of competence depends on each learning situation, the facilitator, and the learners. Therefore, we present these graphics in only the theory segment of the ten steps and not in the examples.

We encourage you as a facilitator and educator to think about the SD competence framework when preparing learning approaches and methods. The radar graphic is a tool to help you in your reflection on how the activities and learning methods you select might help in developing different SD competences. At the end of each step, you may use the graphic as a tool to summarize with learners what was done in the step and whether they felt such competences were gained.

Exploring Systems Thinking with Examples

This manual presents two examples of how to apply the Ten Steps towards Systems Thinking. Two items that may be familiar to young people around the world – jeans and chips – are the main characters in these examples.

These examples offer different levels of complexity. You as the educator may decide which example is more appropriate for your learners. The Jeans example follows the ten steps closely to explore the systems of production of raw materials, their conversion into products and on to the sale and use of jeans. The Chips example presents two parallel lines of work: exploration of potato chip production systems, and the systems around the human body's response to chips consumption.

We also illustrate the use of certain methods. Both examples try to use different methods and activities for learners to acquire different competences suggested in each step. We hope that the activities and methods presented will guide you in strengthening your learners' systems thinking abilities not only for the topics we have included, but for many others of your preference. Through the Ten Steps we present suggestions that you can adapt to your context and needs. This manual is designed for flexible use, in accordance with the needs of the users. We aim to motivate you as an educator and facilitator to create your own material to use with your learners, in ten (or more, or less) steps towards systems thinking.

Jeans

Millions of people are dressed in jeans every day. Learners across campuses prefer wearing jeans. We may have our favourite brands. Some of us may simply wear the ones that are affordable. Others prefer those that are most stylish, or comfortable to wear for daily work. As many of us know, jeans are mostly made of cotton (though fast fashion is driving up the use of polyester). However, we might not really know where the jeans were made and how, and who made them. Nor would we know the conditions in which the jeans were made, and who benefitted or profited from the production and sales of the jeans, and what impact it had on the environment.

Following these few thoughts, you may directly enter the global cotton system. A global pattern of production steps has evolved from the different climatic and farming conditions, availability of water for irrigation, labour work conditions and earnings of farmers and factory workers, industrial processes, status of environmental laws and many other factors. This global system is in a continuous state of change.

As mentioned earlier, the jeans we wear is only one of the outcomes of this system. What else is happening in this system and how does it affect our world? This example of an everyday item of our lives has been chosen to invite learners to try systems thinking.

Chips

All over the world, potato chips of various flavours – traditional, classic, tangy, and even some flavours that many might find strange – have the leading position among all snacks. Nutrition habits all over the world show a remarkable change over the years. Chips accompany the increasing screen time on television, multi-media, video, internet, online learning, and work settings. Snacking and snack varieties are on the rise, especially among youth. The alarming element of the story is that a chips-heavy diet is likely to be unhealthy.

The potato chip navigates the journey from a potato field to the bag of chips in our hands through a global production system. The journey follows the chips through the human body which is a system on its own. These two separate but linked sub-systems form a complex system.

The ‘Chips’ example with its linked sub-systems presents a progression within systems learning.

How to identify a suitable topic?

How may one identify a suitable topic for the development of systems thinking competence? Here are some pointers to keep in mind:

It may be appropriate to choose familiar topics and local scales – these may not be less complex, but easier to understand.

Topics that you may find suitable to explore may include:

- Familiar items like jeans, chips or other food items, car, wooden house.
- Everyday activities and processes like traffic and waste management.
- Natural phenomenon in which humans have intervened, like climate (change), soil formation and dynamics, the water cycle, etc.

Choose a starting point for your ten step exploration: start with an everyday item or situation in your city or village, or analyse a part of nature that you and your learners feel concerned about or interested in.

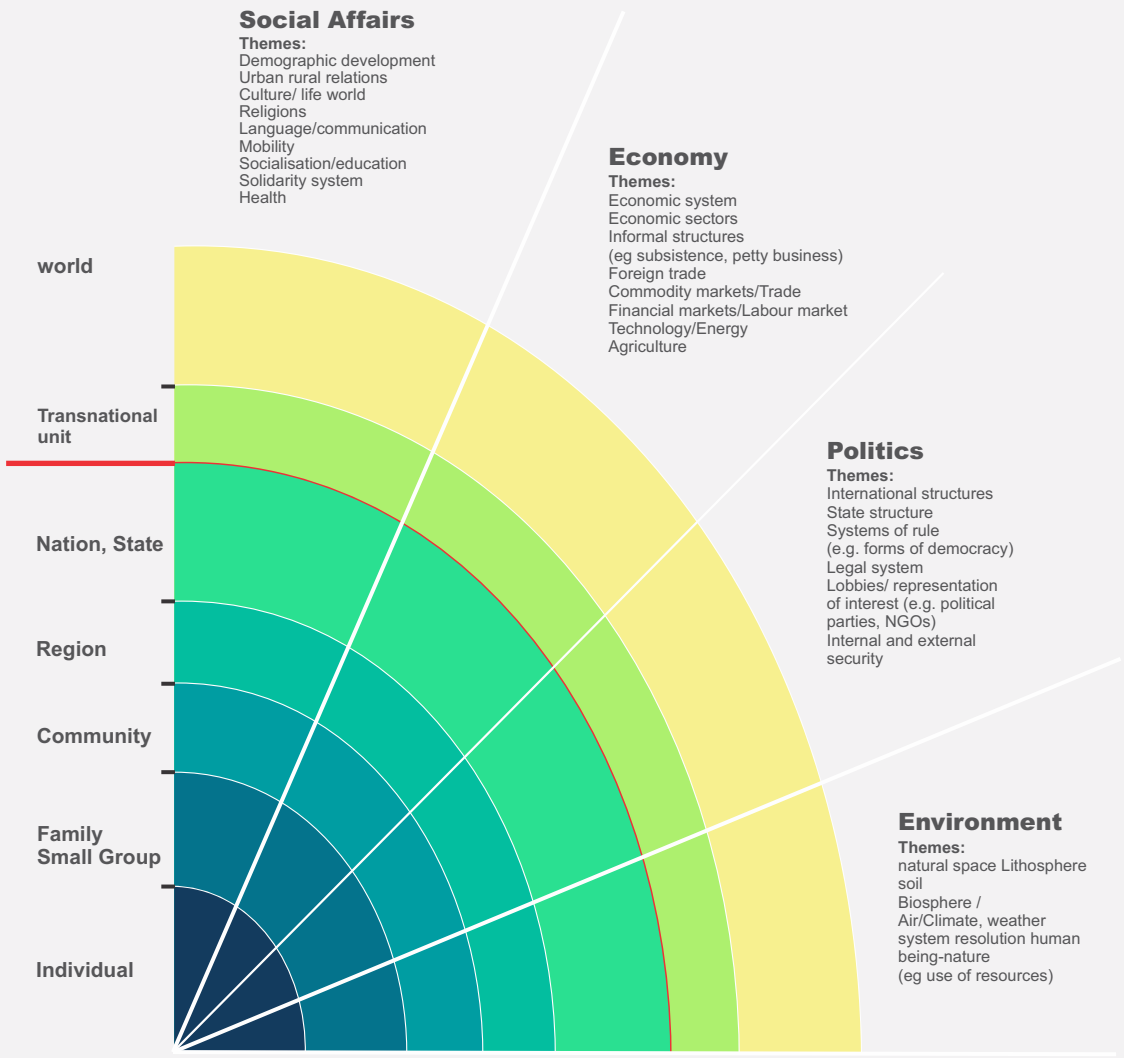
Topics most suited for exploring sustainability issues with a systems approach would touch social, political, economic and environmental dimensions, and could have multiple scales – individual, family, community, region, state/nation, and the whole world.

The figure on the following page is intended to help you choose or appropriately frame a topic for systems learning. The chart presents different dimensions (social affairs, economy etc) and scales (represented in different colours) of development, that may be considered when choosing and analysing specific topics. The red line in the graphic indicates that some topics extend beyond state and country limits.

To check whether a topic would be suitable for systems learning or not, you could draw a chart (or use the table template below) and add key words in each segment, relating to the dimension (social, economy, politics, environment) and the scale (individual, community, etc). The more populated the template is, the better. Recognizing the complexity of issues is a valuable insight.

You may also refer to the Sustainable Development Goals (SDGs), and their targets to find inspiration for systems thinking topics.It is very valuable to have young minds grapple with the challenges that the SDGs present.

Dimensions and Scales of Potential Topics for Systems Learning



Curriculum Framework : Education for Sustainable Development, Fig. 1

Template to add keywords to detail out a topic

Topic:				
Scale/ Dimension	Social Affairs	Economy	Politics	Environment
Individual				
Family, small group				
Community				
Region				
Nation, state				
Transnational (across national boundaries) unit				
World				

THE SYSTEMS STEPS

BEFORE THE STEPS

What is a System?

As mentioned earlier, 'Systems Thinking competence' is one of the eight key competences identified by UNESCO (2017) in the context of education for sustainable development. According to UNESCO "Systems thinking competency is the ability to recognize and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty". This definition has gained international acceptance and is used in this manual.

Before we proceed further on the journey of strengthening 'systems thinking competence', it is helpful to try and understand what a 'system' is!

Donella Meadows described a system as:

"An interconnected set of elements that is coherently organized in a way that achieves something. If you look at that definition closely for a minute, you can see that a system must consist of three kinds of things: elements, interconnections, and a function or purpose."

Meadows, D (2008)

To comprehend this abstract description and relate it to a daily life context, let us consider a bicycle as an example of a system.

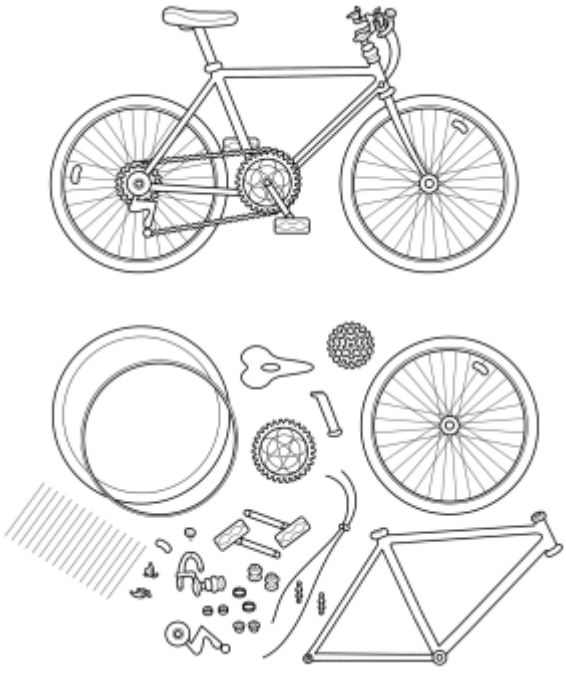
A bicycle is a system because

- It consists of elements such as the wheels, brakes, handlebar, saddle, light etc.
- Connections exist between the different parts - such as pedals, chain wheel, bicycle chain, wheels.
- It has the function or purpose to be ridden and to transport at least one person from one place to another.

Can we consider a stationary bicycle which shows no movement and no rider handling it, as a'system'? Yes. Even in such condition, a bicycle is a 'system' and we may refer to it as a static system. The bicycle when moving and handled by a rider becomes a dynamic system.

Each system has a system boundary. This is not necessarily defined by the system itself but by the question you may ask in the context of thinking about a system or thinking in systems.

To understand this, let us once again refer to the bicycle. We might only consider a bicycle in the narrow boundaries of its original purpose – as a means of transport. But we could also ask: What will happen to my bicycle, if I park it outside my house? In such a scenario, we could consider that the system boundaries would include the various natural processes such as weathering, gradual loss of air in the bicycle tyre, deterioration of the quality of the leather saddle due to weathering processes, etc. One may even expect that the bicycle might be stolen by someone. These examples show that a system may be nested as a sub-system within a larger system, which in turn might be inside yet another system, all of which are part of the earth system. The earth itself is part of the solar system! Whether one touches these multiple systems finally depends on the questions that arise based on one's perception. The next section provides an overview of the steps to explore systems.



Are the parts of a bicycle also a system?

Overview of the Steps

Steps	Activities & learning methods	Learning outputs	Learning outcome
Step 1 Describe and/ or visualise a part of a complex reality.	**Activity** Produce a structured description. **Learning Methods** • Structured description • Back-to-Back sitting • Cinquain • Drawing • Telephone call • Think, Pair, Share • Taboo!	A written or graphic description of the reality.	**Ability to** • Describe, • Intensify one's perception about the chosen topic.
Step 2 Express that part of reality as a model.	**Activity** Create a model. **Learning Methods** • Brainstorming • Think, Pair, Share • Interview • Understanding Causation • Mapping Technique: Mind Map, Flowchart • Picture to Reality • Station Learning • Web of Life	Use the output from Step 1 to create a model.	**Ability to** • Gather information, review, and learn from examples and secondary research (data that already exists), • Develop a model, • Collaborate to share information and insights, • Improve one's understanding about a topic and its components.
Step 3 Understand the model as a system.	**Activity** • Check whether the model is static or dynamic. • Provide examples to identify systems. **Learning Methods** • Mapping technique • Advocatus Diaboli • Analysis Matrix • Understanding Causation • Moving Game • Station Learning • Think, Pair, Share • Web of Life	Use the output from Step 2 to develop: • A description of (parts of) the model using systems vocabulary, and • System(s) diagram(s), including causal loops to represent dynamism, stocks, and flows.	**Ability to** • Evaluate whether a model represents a system, • Differentiate between a model and a system, • Understand if a given or developed model represents a system, and if not, review the information that is the basis of the system; go back to Step 2, or even Step 1, • Understand a system.

Step 4 Use the model to explain the behaviour of the system.	**Activity** • Explain the model. • Create a Behaviour over Time (BOT) graph for selected elements. **Learning Methods** • Moving Game • Understanding Causation • BOT graphs • Explainer Video • Podcast • Outsider • Taboo	Use the output from Step 3 to prepare: • Text or oral description of the past and recent behaviour of the system and selected elements, • BOT graphs of the past up to the present.	**Ability to** • Observe changes, • Explain the nature or trend of change, • Explain the cause of changes (interrelations and causation), • Visualize information in different forms, • Communicate complex topics, • Understand that a system is dynamic. • Revise the model if it is not suitable to explain the dynamism of the system. Then, review Step 3.
Step 5 Anticipate the behaviour of the system.	**Activity** Conduct a Scenario Analysis of the model. **Learning Methods** • Structured Description • Understanding causation • Behaviour-over-time graphs • Scenario Analysis • Explainer Video • Podcast	Use the output from Step 4 to prepare: • A description of (parts of) the model using systems vocabulary, • System(s) diagram(s), including causal loops to represent dynamism, stocks, and flows.	**Ability to** • Anticipate the near future, including impacts on the (some or all) components of the system, or different elements of the system that are of interest.
Step 6 Evaluate the impacts of the system on sustainable development (SD).	**Activity** • understand the concept and options of measuring (sustainable) development, • understand the concept of SD, • Evaluate the future of the chosen topic under the frame of SD. **Learning Methods** • SDG Analysis Matrix • Advocatus Diaboli • Indicator Eggs • Group Jigsaw • Panel Discussion • Role Play (e.g., Model UN Conference)	Use outputs from Steps 3, 4 and 5 to prepare: • List of criteria of SD applicable to the chosen topic, and selected variables, • Written evaluation, including any existing contradictions and conflicts for SD.	**Ability to** • Evaluate situations as they change over time, in accordance with selected frameworks of sustainable development and any criteria of interest, • Identify contradictions and understand them as reasons for current and future conflicts, • Recognize the consequences of and reflect on necessary steps or activities to enable or strengthen SD. • Think critically.

Step 7 Identify potential points of intervention.	**Activity** Identify points of intervention in the system using examples. **Learning Methods** • Video Content Analysis • Brainstorm • Transfer	Use the out put from Step 3 (Systems diagram) to mark points of intervention.	**Ability to** • Understand what a 'leverage point' is, • Identify points of intervention, or 'leverage points'.
Step 8 Identify potential types of interventions.	**Activity** Identify types of intervention in the system using examples. **Learning Methods** • Transfer • Explainer Video • Podcast	Use the output from Step 7 to prepare a description of one or more potential interventions.	**Ability to** • Think critically, • Understand how to use leverage points according to the intended change in the system.
Step 9 Generate options to act for SD.	**Activity** Design the aim (oriented to sustainability), and a strategy to achieve the aim. **Learning Methods** • Narration and storytelling • Future Workshop • Debate • Back casting • Scenario Analysis • (SDG) Analysis Matrix	Use the outputs from Steps 7 and 8 to select an intervention and • Name the intended SD outcome, • Describe the selected intervention to achieve the intended SD outcomes, • List anticipated consequences of the interventions.	**Ability to** use the understanding about systems and SD to: • State the SD changes desired, • Select and detail out an intervention to bring about the desired SD changes, • Describe the anticipated impacts if the intervention is carried out/ implemented, • Deal with dilemmas.
Step 10 Assess the impacts of interventions on SD	**Activity** Assess if the intervention strategy for changing the system towards sustainability is successful. **Learning Methods** • Think, Pair, Share • Debate • Advocatus Diaboli • Group Jigsaw • Role play (for example organizing a jury) • (SDG) Analysis Matrix • Explainer video • Podcast	Use the outputs from Steps 3, 4 and 5 (systems diagram and systems behaviour descriptions), and the intervention/s selected in Step 9, to prepare • a list of intended and unintended impacts, • a written evaluation of the interventions, using the selected Sustainable Development frame (of Step 6).	**Ability to** • Anticipate and reflect on intended and unintended impacts of interventions, • Evaluate and qualify anticipated impacts on sustainable development, • Review Steps 7, 9, or even 3 if the impacts originally planned are unlikely to ensue or not optimal for SD, • Tolerate frustration and deal with ambiguity.

STEP 1

DESCRIBE A PART OF A COMPLEX REALITY

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What does this mean?

To understand reality in a deeper way, it is necessary to focus on a part of it, while recognizing that this is part of a larger whole. This can start by choosing topics the learners feel interested in or concerned about, which may range from the jeans one wears, or chips young people love to snack on, or social or living conditions in one's city, or any other topics.

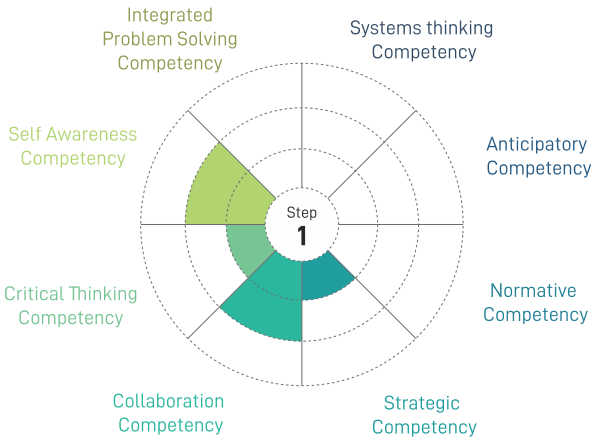
The first step to acquiring systems thinking competence is to recognize the multi-faceted nature of topics and be able to express it in words (as a description) or as a sketch (as a visualisation). A description may be an oral or written account, while a visualisation may be a sketch, diagram (map, landscape), event, or situation.

2. What is the aim?

To enable learners to

- Produce a structured description of the chosen topic, including
  - constituent elements, such as natural and human-made, tangible and intangible
  - numbers or quantities, if relevant
  - perceptions and feelings about the object, situation or chosen topic.
- Self-reflect on their prior knowledge, recognize that knowledge can be gained from many sources, and develop the ability to seek out information.

Potential for Competence Enhancement in Step 1



3. Teaching approaches

The description of reality should consist of physical elements and context. This description may be done in as much detail as possible, including:

- Constituent elements, such as natural and human-made, tangible and intangible.
- Numbers or quantities, trends (increasing or decreasing), if relevant.
- Perceptions and feelings about the topic.
- What is considered as part of the topic?
- What are the things that could affect the topic?

Learning methods

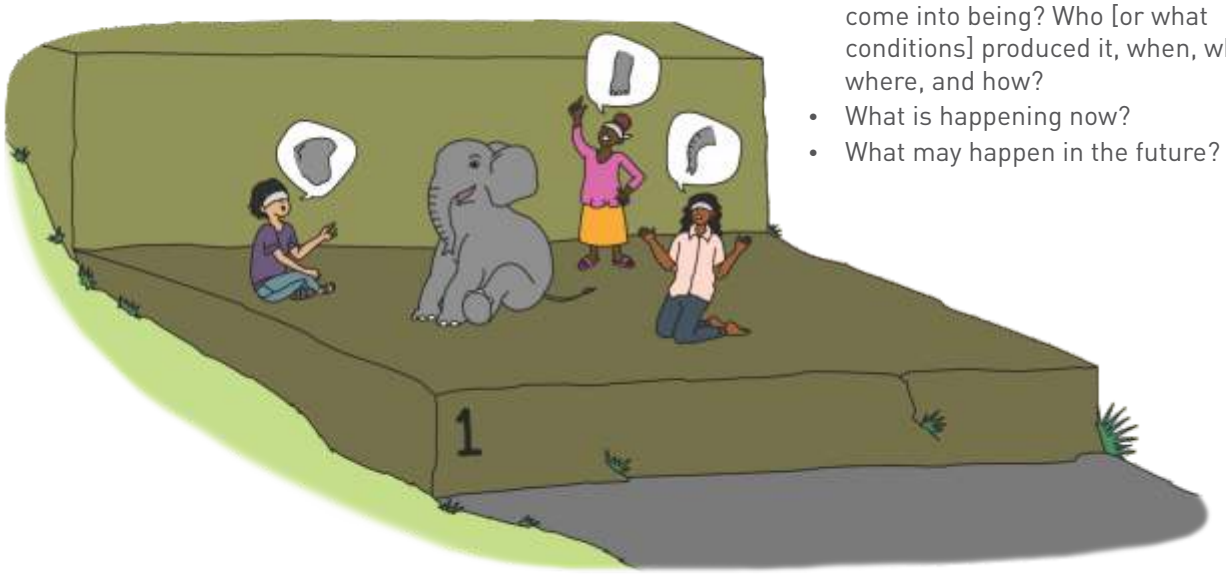
- Structured Description
- Back-to-Back Sitting
- Cinquain
- Drawing
- Telephone Call
- Think, Pair, Share
- Taboo!

4. Conclusion

- Reflect on what is learnt thus far, either by summarizing the activity or asking learners to do so.
- Reflect on the process of synthesizing, share your knowledge or information, and gather additional information from others.
- Ask the group to think and share further leading questions about the object or situation.
- The answers may be discussed in the next steps.

5. Examples

Step 1 in the Jeans example
Step 1 in the Chips example



Further leading questions

- How did the object or situation come into being? Who [or what conditions] produced it, when, why, where, and how?
- What is happening now?
- What may happen in the future?

STEP 2

EXPRESS A PART OF REALITY AS A MODEL

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, **express that part of reality as a model,** understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What does this mean?

In Step 1 the learners created a detailed structured description. In Step 2, they build on the structured description to create a model, by identifying each element of the chosen topic, the connections or interrelationships between the constituent elements, and how they work together. This will help to develop a deeper understanding and open new perspectives about the topic and its status.

What is a model?

A model is a simplified picture or depiction of a part of reality.

The aim of (scientific) modelling is to clarify and organize one's own thinking and make it shareable with and communicable to others.

To do this you select and identify relevant components or elements and (inter) linkages of a topic, that express what you perceive about the topic at that moment. You might use different kinds of models to strengthen understanding about the topic. For example:

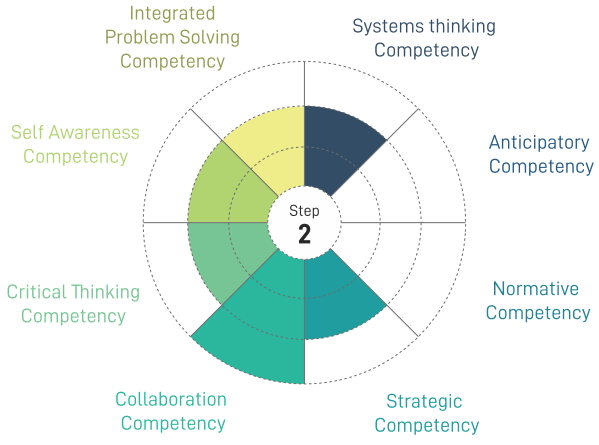
- A globe is a 3D model
  A globe is a model of the much more complex world. But the globe depicts the position of the continents and oceans, gives us an idea of topographic relation of mountain ranges, rivers, or states etc. The globe makes the earth more understandable, while in reality, it is a very complex system!
- A diagram of the water cycle is a graphical model
  The global water cycle is a well-known model. It visualizes the evaporation of water over the oceans and condensation resulting in the formation of clouds. These clouds cause precipitation over the oceans and, driven by winds, also over land. Precipitation feeds ground water, as well as surface waters in the form of creeks and rivers, which finally end up in the oceans again, and the cycle starts all over again.
- An equation is a conceptual model
  The Pythagoras theorem states that the area of the square whose side is the hypotenuse (the side opposite the right angle) is equal to the sum of the areas of the squares on the other two sides. The theorem is written as an equation, $c^2 = a^2 + b^2$, where c represents the length of the hypotenuse and a and b the lengths of the triangle's other two sides.

2. What is the aim?

To enable learners to

- Enrich the description of reality created in Step 1,
- Convert the structured description into a model (static model), and
- Assess the quality of the model.

Potential for Competence Enhancement in Step 2



3. Teaching approaches

The learners have to develop a model using the structured description produced in Step 1. For this, the learners may be engaged in activities such as the following:

- Create a list of keywords from the structured description of Step 1, by using a method such as Brainstorming and classify these as elements, interrelationships, and functions.
- Translate the words into signs and signs to words, using the Worksheet 'Words to Signs to Words'.
- Convert a photograph to a model, using symbols and arrows, using the Worksheet 'Transfer reality to model'.
- Make a mind map using the structured description output of Step 1 as a starting point.
- Share the water cycle diagram or conduct Web of Life (Learning Method) if learners require to understand better what a model is.
- Learners may realize they are unable to describe the model sufficiently. Encourage them to explore different ways to find out about and fill in the missing information and elements in their description. For example, they may conduct an interview, search the web, or refer to appropriate literature to update their understanding.
- Finally, the learners have to create a model. See the box 'How to Make a Model?', below.

How to Make a Model with Visualization?

Models can be simple or complex. To design models, it helps to follow Albert Einstein's advise: "Everything should be made as simple as possible, but not simpler."
Visualizing is one of the ways to create a model. It allows one to structure knowledge of more or less complex topics. It uses words, arrows, logos, or pic to grams as symbols of interrelated components of the topic.

The following steps must be considered when designing a model:

- Define the question or the intended purpose of the model.
- Obtain and collect the necessary information.
- Evaluate which pieces of information are in a causal relation to others, and therefore necessary to understand the chosen topic. You might have to convert concrete items of information into abstract terms or icons.
- To create the model,
  - Give it a heading.
  - Arrange the elements in a logical order of time, levels, or spatial or geographic positions, as appropriate for the chosen topic.
  - Use icons where suitable and prepare an explanatory legend.

Learning methods

- Brainstorming
- Think, Pair, Share
- Interview
- Understanding Causation
- Mapping Technique: Mind Map, Flowchart
- Picture to Reality
- Station Learning
- Web of Life

Worksheets

- Words to Signs to Words
- Transfer Reality to Model
- Analyse your Model

4. Conclusion

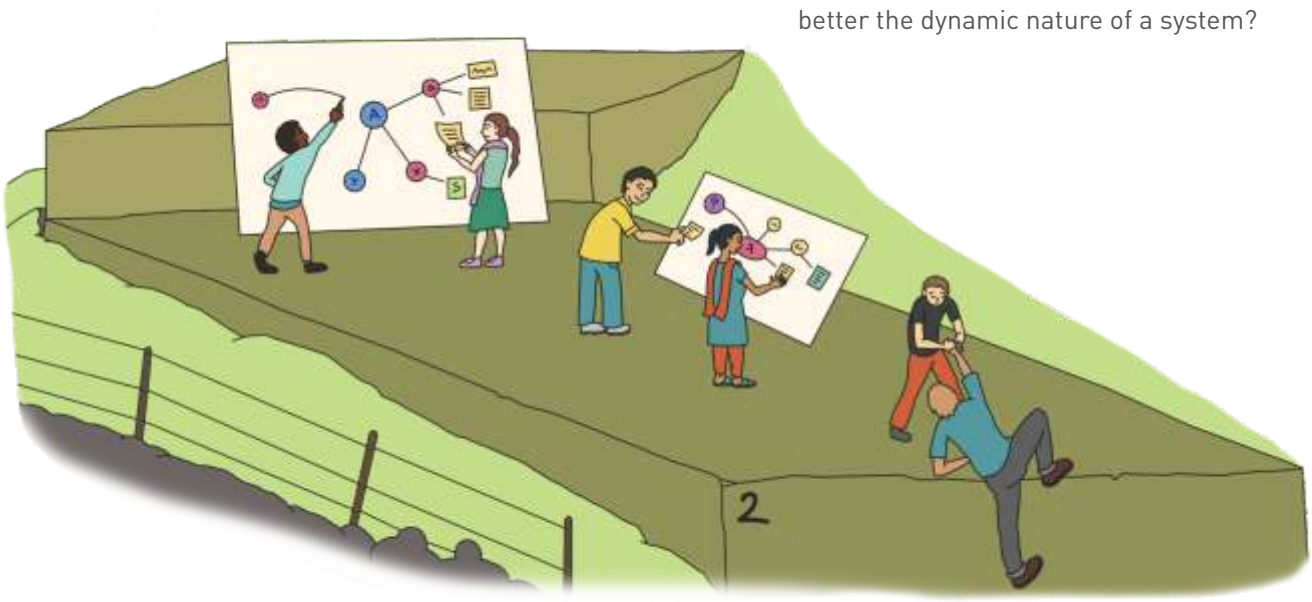
- Reflect on what is learnt, either by summarizing the activity or asking learners to do so.
- Reflect on the process of converting a structured description into a model and assessing the quality of the model.
- Ask the group to think about and share further questions about the model.
- The answers to these further leading questions may be discussed in the next steps.

5. Examples

Step 2 in the Jeans example
Step 2 in the Chips example

Further leading questions

- Does the model adequately explain the topic?
- Is the model suitable to understand the reality of the topic which may change in the next moment, or tomorrow, or sometime in the future?
- Should we look for models that can depict better the dynamic nature of a system?



STEP 3
UNDERSTAND THE MODEL AS A SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, **understand the model as a system,** use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What does this mean?

Having prepared a model in Step 2, learners review whether it depicts a static or dynamic (changing) reality. Next, learners assess if the model they have developed, (or are given, in case the facilitator so decides) represents a system.

What is a "system"?

The Greek called a unit put together out of various elements or components "systema", from which the word "system" has been derived. In our contemporary understanding, a "system" is understood as a coherent or functional unit incorporating many different factors and drivers, which are interconnected and interdependent. A system is more than the sum of its parts. A forest is a type of ecosystem, and therefore much more than a simple sum of the number of its trees.

Any system has:

- elements,
- interrelationships between the elements.
- function or purpose.

Systems show typical behaviours or patterns of change such as causal or feedback loops, growth, decay (reinforcing) in linear or exponential manner, oscillations, or stabilising (balancing) behaviour.

The behaviour of a system is the set of expected changes over time, as long as it is allowed to function normally. For example, the seasons are a normal behaviour of the climate system.

It is the structure of the system itself, and therefore the nature of interactions among the elements that causes development and change.

A system is dynamic, though the whole system can also come to a stand-still and behave in a static manner for a certain period of time. For example, the climate, the economy, society, factories, farms, schools, and nature are systems. A bicycle which is stationary and not being handled by a rider, is also a system; standing still or having no movement is a particular instance of the behaviour of a system.

Systems can be self-organizing, self-repairing over at least some range of disruptions. They are resilient, and many of them are evolutionary.

Systems thinking requires a specific vocabulary; the terms that may be introduced in this Step 3 are:

- element
- interrelationships and causation
- function
- system
- dynamic
- boundary
- behaviour
- systems are nested within a larger system.
- stocks and flows

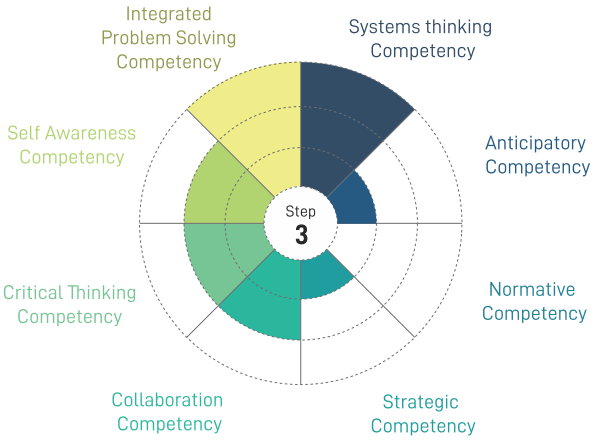
(For more details, please refer to *Thinking in Systems* by Donella Meadows, published by the Sustainability Institute, 2008).

2. What is the aim?

To enable learners to

- understand whether the chosen topic is a system or not, and whether the system is static or dynamic in nature
  - become familiar with and use the specific vocabulary of systems approaches (such as element, interrelationship, function, system, dynamism, etc.)
  - identify elements such as actors or factors of the chosen topic,
  - identify interrelationships among elements in the chosen topic, such as processes, communications, energy or information flows, cultural norms, legislations, or rules,
  - understand that co-functioning elements and interrelationships cause dynamism of systems,
  - understand that a system has integrity (functions as a unit) and has a boundary,
  - understand that a system may be nested as a 'sub-system', within another system, or even within other systems,
  - list the outputs of the system/ subsystems
  - identify a range of systems in their own contexts and in the world.

Potential for Competence Enhancement in Step 3



3. Teaching approaches

In this step, the learners use the model prepared in Step 2 to understand it as a system.

Activity 1

- The learners may initially be engaged in a brief discussion of examples of obvious systems as well as the not so obvious ones:
  - Examples of a range of obvious small and large systems, physical to social-ecological, such as a bacterium, ants nest, a pasture, a grocery shop, a school, the transportation system of a city, the climate system.
  - Bicycle - Are the parts of a bicycle a system? Is a bicycle a system? Are a bicycle and its rider together a system?

    (The parts of a bicycle separated out are not a bicycle; however, they are part of the earth system just like billions of other physical objects.).
  - Objects by themselves, and collections of objects arranged in relationships - are these systems?
    - Wind chimes
    - A building, a building with its occupants
    - A painting on a wall; a painting with a viewer

      (Yes, they are!)
- You may also share systems examples from Step 3 in Chips or Jeans.

Activity 2

- Learners should check whether the model they prepared in the previous step is static or dynamic. In case they recognize missing knowledge to depict their model, they may conduct an interview, or search the internet, or refer to appropriate literature.
- To get a better understanding of the progress of your learners, ask:

  What drives the behaviour of their system?

  Do they realise that there is a feedback process involved in the behaviour of systems?
- Finally, the learners should develop:
  - A description of (parts of) the model using systems vocabulary,
  - System(s) diagram(s), including causal loops to represent dynamism (see the method Understanding Causation).

Learning methods

- Mapping technique
- Advocatus Diaboli
- Analysis Matrix
- Understanding Causation
- Moving Game
- Station Learning
- Think, Pair, Share
- Web of Life

Resources

Meadows, D (n.d.). *Dancing With Systems.* The Academy for Systems Change. Available at https://donellameadows.org/archives/dancing-with-systems/

4. Conclusion

- Reflect on what is learnt, either by summarizing the activity or asking learners to do so.
- Reflect about the model - is it static or dynamic?
- Reflect on the process of synthesizing knowledge or information, expressing it, and gathering additional information from others.
- Ask the group to think about and share further questions.
- The answers to these further leading questions may be discussed in the next steps.

5. Examples

Step 3 in the Jeans example
Step 3 in the Chips example

Further leading questions

- What is the use of representing reality as a system?
- Does the behaviour of the system remain the same over time, or does it change?
- What drives the behaviour of a system?

STEP 4

USE THE MODEL TO EXPLAIN THE PAST BEHAVIOUR OF THE SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, **use the model to explain the behaviour of the system,** anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What does this mean?

In Step 3, learners recognized that a model of a system helps to understand its functioning.

In Step 4, the learners perceive that the reality or behaviour of the system at a given time is a momentary, or short-term result of visible or hidden processes. The reality at a given time is like a snapshot of the behaviour of the system at that time, discerned by observing selected parameters.

For example, the health of a eutrophic pond ecosystem could easily be estimated by observing algae blooms, as compared to a chemical analysis of the water.

To understand the nature of change of the system, we have to observe several snapshots that show the patterns of behaviour over time (BOT), which may remain stable (or constant), or change over time. Change could be attributed to a combination of both internal and external drivers, and to changing contexts.

Furthermore, the behaviour of a system may change in different contexts which are external to the system, or outside the system boundary, since systems are nested within larger systems. For example, a factory in one part of the world may operate differently than one in another part, due to the local political, climatic, and other conditions.

System structures are of two types, balancing and reinforcing, with associated behaviour patterns. The analysis of the model could show a balancing or reinforcing pattern or behaviour.

Balancing behaviour means that contrary flows neutralize each other.

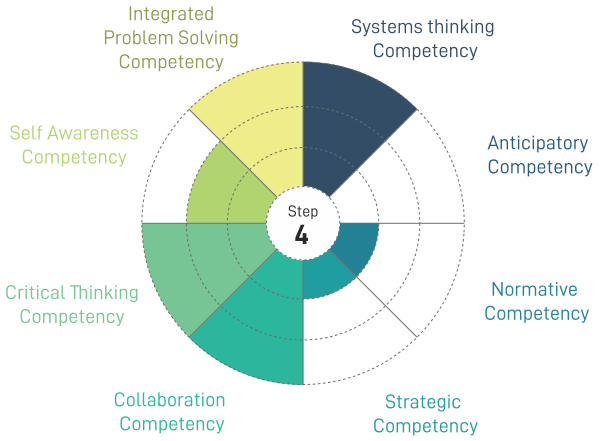
Reinforcing behaviour means that different flows come together and strengthen an effect.

The system as a whole may display one or the other behaviour at a given time, while both behaviours may be present within a system, in different subsystems.

2. What is the aim?

To enable learners to explain the past behaviour of the system over time.

Potential for Competence Enhancement in Step 4



3. Teaching approaches

By now learners understand elements and feedback processes. In this step, the learners use their understanding acquired in Step 3 to explain how a single element in a given system behaves over time.

Activity 1

Materials

Writing materials

Procedure

Ask learners to describe the following:

- Level of daylight from sunrise to sunset
- Size of the moon over a month, starting from a full moon night to a new moon night
- The height of a tree, from the moment it germinates from a seed to attaining its height.

Ask them to prepare line graphs for each situation that depicts the change over time. Different graph shapes emerge.

Activity 2

Animation link

https://upload.wikimedia.org/wikipedia/commons/8/8e/Adoption_SFD_ANI.gif

The animation depicts a model of new product adoption. Over time the number of people who adopt the product goes up. The number of potential adopters comes down. The number of innovators, and imitators goes up initially, and then comes down.

Procedure

Let the whole group view the animation. Now form four groups. Ask each group to plot a graph depicting the numbers over time (15 years) of the following:

- potential adopters
- innovators
- imitators
- adopters

Are the graphs similar? No. The behaviour of an element within a system may be different from the behaviour of the system as a whole.

Learners may be encouraged to take up additional activities to enhance their understanding of models, by tasks such as:

- Explain a given model.
- Learn how to assess the quality of a model (see the Worksheet 'Analyse your Model').
- Learners may review their own model developed in the previous step or a given model, and try to improve the model if needed.

Learning methods

To understand interrelationships and causation*:

- Moving Game
- Understanding Causation

*use the water cycle model to train on how to explain a model and causation.

To communicate and make a logical argument:

- Outsider
- Taboo!

Finally, the learners should develop a text or oral explanation of the past and recent behaviour of the system and certain elements, using

To explain system behaviour (presented as slides or in a flipchart):

- Behaviour over Time Graphs of the past up to the present
- Understanding Causation
- Explainer video
- Podcast

Worksheet

Analyse your Model

4. Conclusion

Reflect on what is learnt thus far, either summarizing the activity or asking some of the learners to do so. In this step, learners should have understood that:

- Systems are dynamic
- The structure of systems determines their behaviour.

Ask the group to think about and share further questions.

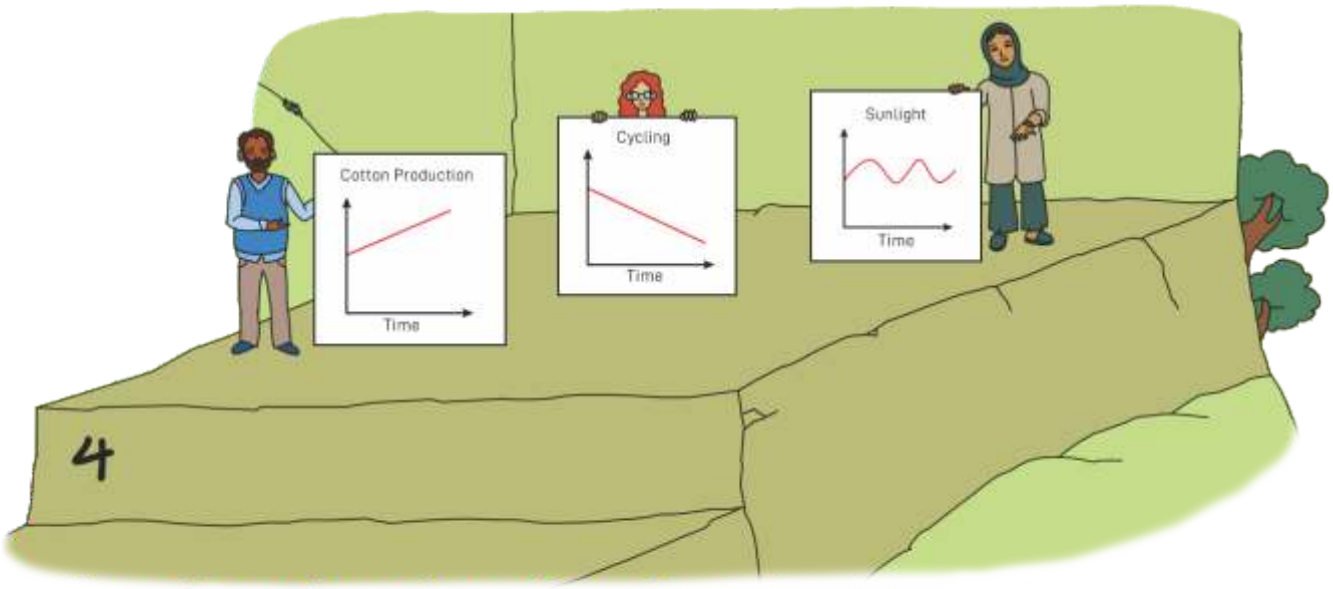
The answers to these further leading questions may be discussed in the next steps.

5. Examples

Step 4 in the Jeans example
Step 4 in the Chips example

Further leading questions

- Can you look into the future with the help of a system model?
- Do similar system structures produce the same pattern of change?
- Do similar system structures have the same function?
- Do similar system structures behave the same way in different contexts?

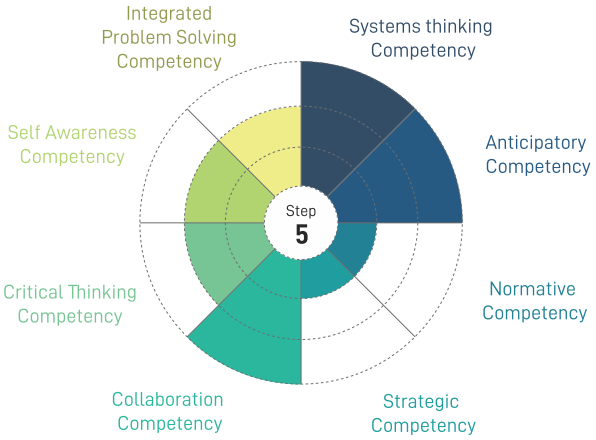


STEP 5

ANTICIPATE THE FUTURE BEHAVIOUR OF THE SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, **anticipate the behaviour of the system,** and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

Potential for Competence Enhancement in Step 5



1. What does this mean?

In the previous step, learners explored the past behaviour of the system. In this step, with the help of the developed systems model, the learners can make forecasts or projections of future situations of the chosen topic. The projections are determined by the constituent elements, interrelationships, and drivers including external stimulations and internal feedback loops. For example, weather models used by meteorology departments can provide a weather forecast for a region tomorrow, or the next few days.

2. What is the aim?

To enable learners to:

- Recognize that it may be possible to anticipate potential futures of the chosen topic using a systems model.
- Use systems models to make projections about the chosen topic.

3. Teaching approaches

In Step 4, learners developed explanations of the past and recent behaviour for selected elements of the system. In this step, the learners use their understanding of the behaviour of particular elements within the system, as well as the dynamism of systems as a whole, and apply it to anticipate the future behaviour of the system.

Learners can use Understanding Causation as a preparatory activity. The Scenario Analysis method is helpful for imagining the behaviour of multiple elements and more or less the whole system. The results of the Scenario Analysis may be presented in the form of a slide show, a series of charts or an Explainer Video or podcast.

Finally, learners should develop:

- A textual or oral Structured Description of the expected future behaviour of the system and certain elements of the chosen topic or reality.
- Behaviour-over-time graphs, presenting the projections for how the system is anticipated to behave in the future.

Learning methods

- Structured Description
- Understanding causation
- Behaviour-over-time graphs
- Scenario Analysis
- Explainer Video
- Podcast

4. Conclusion

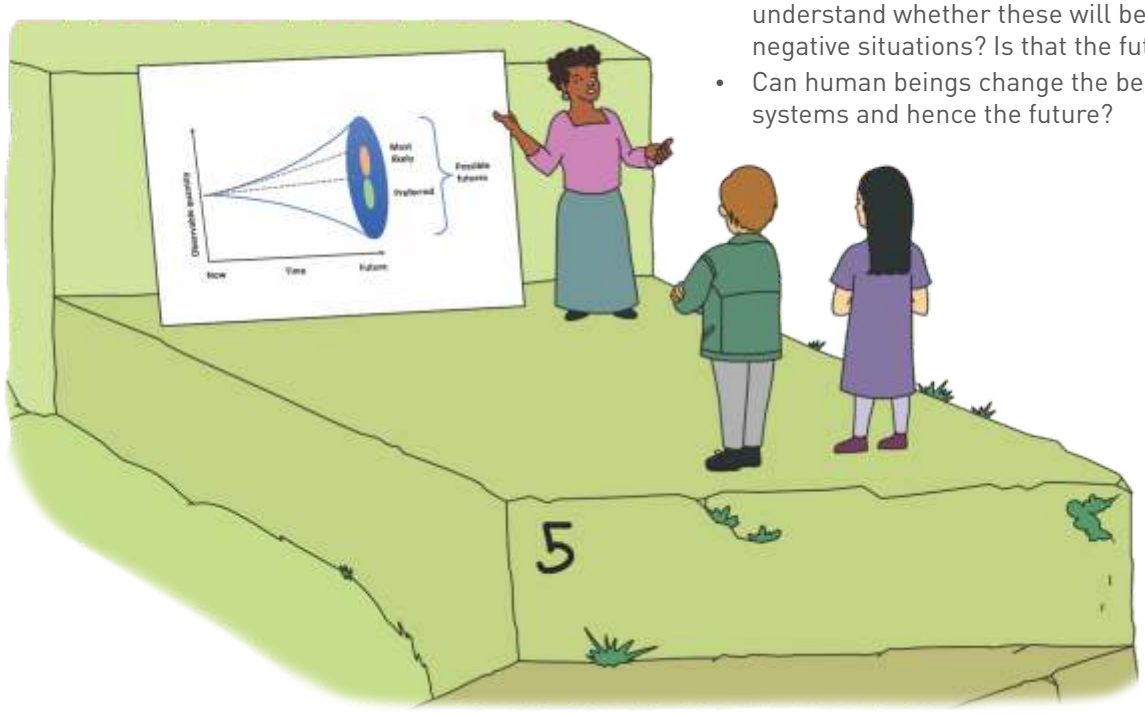
- Reflect on what is learnt, either by summarizing the activity or asking learners to do so
- In this Step, learners should have understood that it is possible to anticipate the future using an understanding of systems, get insights on the best- and worst-case situations in the future.
- Ask the group to think about and share further questions about the system they are exploring.
- The answers to these further leading questions may be discussed in the next steps.

5. Example

Step 5 in the Jeans example
Step 5 in the Chips example

Further leading questions

- What is the use of looking into the future (with a systems model]?
- Having anticipated future situations with the help of systems analysis, can you also understand whether these will be positive or negative situations? Is that the future you want?
- Can human beings change the behaviour of systems and hence the future?



STEP 6

EVALUATE SYSTEM BEHAVIOUR IN THE FRAME OF SUSTAINABLE DEVELOPMENT

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and **evaluate** its **impacts on sustainable development,** identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What does this mean?

In the first five steps, learners would have developed and applied their understanding of systems thinking. They would have created a systems model of their chosen topic and made projections about the behaviour of the system in the future. In this step, learners are introduced to the concept of sustainable development (SD). They assess whether and how the system contributes to sustainable development, and if it would continue to do so.

If the system contributes to SD, then what are the ways of maintaining and perpetuating it? In case it does not, or rather if it increases unsustainable behaviours, such as pollution, then, what are the ways of changing the system? These dimensions are discussed in the next steps (Step 6 onward).

For this, it is essential to:

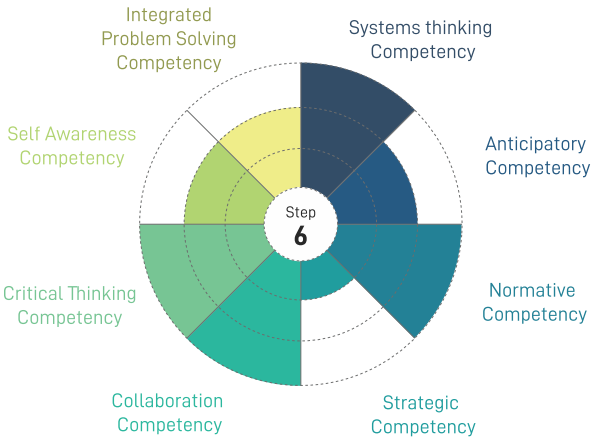
1. Understand the criteria of SD.
2. Identify current and future impacts of the system.
3. Assess the anticipated impacts of the system in the frame of sustainable development. The impacts may be internal as well as external to the system. Moreover, there may be dilemmas in classifying the impacts as for, or against, SD.

2. What is the aim?

To enable learners to:

- become aware of the concept of SD,
- become aware of various frameworks and criteria, and their strengths and limitations, to assess development or SD,
- evaluate the current and future behaviour of selected parameters of a system for their impact on SD.

Potential for Competence Enhancement in Step 6



3. Teaching approaches

In this step, first, the learners become familiar with various concepts of Sustainable Development, such as Gross Domestic Product (GDP), Human Development Index (HDI), Ecological Footprint, Handprint, and the UN 2030 Agenda for Sustainable Development (17 SDG). They should be exposed to the strengths and limitations of these. The 2030 Agenda is recommended as the framework for SD to be used in this manual.

Preparatory Activities

As a preparatory step, invite the learners to watch videos such as "The Story of Stuff" and on the topic of the 2030 Agenda, or conduct the activity Indicator Eggs.

Activity

- Share the information sheet 'What is Sustainable Development?'
- Ask the learners to recall Step 4, in which they described the functions and behaviours of the system and its subsystems as well as Step 5, in which they projected the expected behaviour of the system and its subsystems.
- Now, using the framework of sustainability, learners try to link the system components and their behaviour with one or more of the 17 Sustainable Development Goals and their Targets. Learners can refer to the website about the UN Sustainable Development Goals.
- Share the worksheet 'Measuring Development' for the learners to analyse their system in the frame of SD.
- Do learners encounter any dilemmas? For example: is it always possible to clearly identify whether the behaviour of any element in the system is becoming more or less sustainable? Is improved sustainability in one element happening at the cost of another? Learners should make a note of these dilemmas and come back to these in subsequent Steps.
- Finally, learners should develop:
  - A list of criteria of SD applicable to the system, and selected variables.
  - A written evaluation, including a list of identified contradictions and conflicts for SD that already exist, or may exist between different aspects of the system.

Learning methods

- Analysis Matrix
- Advocatus Diaboli
- Indicators Eggs
- Group Jigsaw
- Panel Discussion
- Role Play /Analytic Team or Model UN Conference

Information sheet

What is Sustainable Development?

Worksheets

Measuring Development

Resources

The Story of Stuff Project (2009, April 23). *The Story of Stuff.* [Video]. YouTube https://www.youtube.com/watch?v=9GorqroigqM

United Nations Development Programme (UNDP) (2015, September 25). *Transitioning from the MDGs to the SDGs.* [Video] YouTube https://www.youtube.com/watch?v=5_hLuEui6w

United Nations. (2017, August 19). *Sustainable Development Goals: Improve Life All Around The Globe.* [Video]. YouTube https://www.youtube.com/watch?v=kGcrYkHwE80.

United Nations (2020, September 19). *Nations United: Urgent Solutions for Urgent Times.* [Video]. YouTube. https://www.youtube.com/watch?v=xVWHuJOmaEk

Website about the UN Sustainable Development Goals https://sdgs.un.org/goals

4. Conclusion

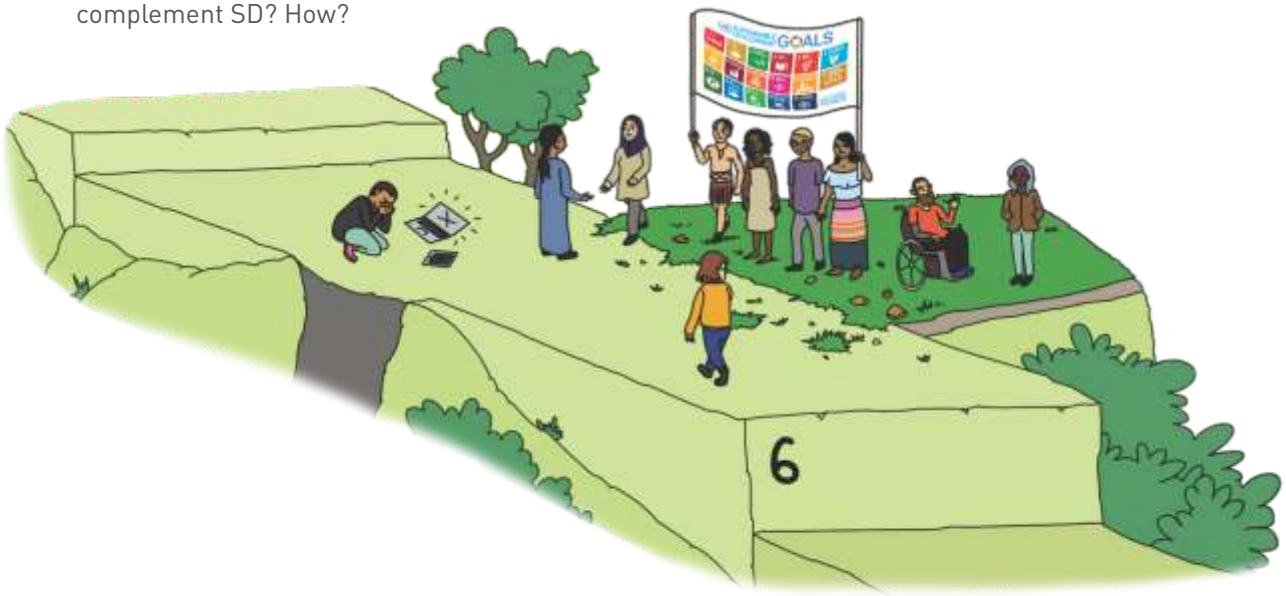
- Reflect on what is learnt, either by summarizing the activity or asking the learners.
- Ask the group to think about and share further questions about the system they are exploring. The answers to these further leading questions may be discussed in the next steps.

5. Examples

Step 6 of the Jeans example
Step 6 of the Chips example

Further leading questions

- Can I influence future developments?
- Can I influence future developments to complement SD? How?



STEP 7
IDENTIFY POTENTIAL POINTS OF INTERVENTIONS

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, **identify potential points** of, and types **of interventions,** generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

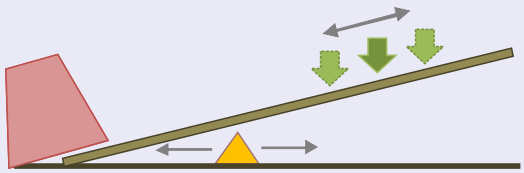
1. What does this mean?

The learners already know that systems have dynamic behaviour. In this Step they learn that it may be possible to change the behaviour of the system consciously or with a specific intention.

The first step is to identify where to intervene in the system, that is, identify 'leverage points' as points that are most likely to succeed in changing the behaviour of the system such that it has the desired impact.

What is a leverage point?

In the physical world, 'leverage' occurs when an input of force into a system generates a greater output force. Leverage is about relative efficiency and efficacy of possible interventions. A 'leverage point' within a system is that point where you place your 'lever' to cause the maximum intended impact, with a minimum of input, such as efforts or funds.



Ask the learners to use the concept maps illustrating the chips and jeans systems examples, where the leverage points are marked.

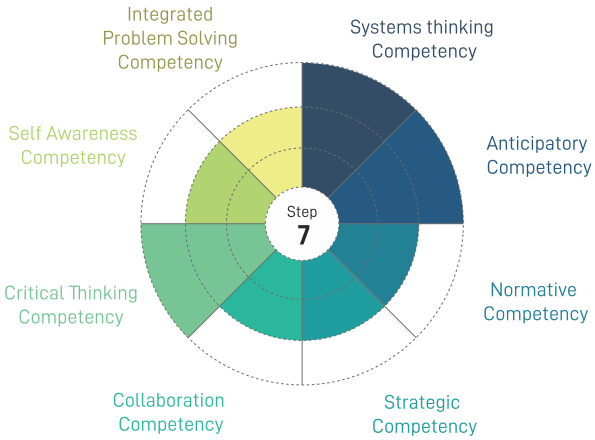
- Concept map of the Jeans system with leverage points
- Concept map of the Chips system with leverage points

2. What is the aim?

To enable learners to:

- Understand what a leverage point is in the context of a system.
- Understand there may be different leverage points with different efficacies within a system.
- Apply their understanding to identify leverage points in their systems.

Potential for Competence Enhancement in Step 7



3. Teaching approaches

First, help learners understand what a leverage point is:

- Show the video "[Rush] - Niki Lauda meets his wife".
- Facilitate a discussion to identify different leverage point(s) in the Niki Lauda story. (These

include for example: the gear stick, attraction between people, capacity of the engine).

- Discuss how the speed of a moving vehicle, say a bicycle, car or boat can be controlled (especially, if it is not possible to use the Niki Lauda video). For example, in a car, the gear stick is a leverage point.In a boat, it is the paddle. Are there other leverage points as well? (E.g., the accelerator or the brake in a car).

Having learnt about Leverage Points, learners may

- Take a good look at their system model and identify such components that can influence the behaviour of other elements. Are certain components in the system model more influential than others. Do changes in these components ultimately cause the system to behave in a certain way?
- Compare the effect of the behaviour of particular elements on the behaviour of the whole system. The more influential components may be "leverage points".
- Think about the part of the system they should intervene in, to change the behaviour of the system.

Finally, learners use the output and discussions of Step 3 (systems diagram) to mark leverage points in their system diagram.

Learning methods

- Brainstorming
- Transfer
- Video Content Analysis

Resources

Meadows, D. (1999). *Leverage Points: Places to Intervene in a System.* The Sustainability Institute. https://donellameadows.org/wp-content/userfiles/Leverage_Points.pdf

[Rush] - Niki Lauda meets his wife, Rush [Film, 35 mm]. Eaton, Andrew et al. Exclusive Media Group and others. USA, 2013. Duration 4 minutes 56 seconds. Walter White (2017, March 17), YouTube https://www.youtube.com/watch?v=3Kl0UBS4ZaM

4. Conclusion

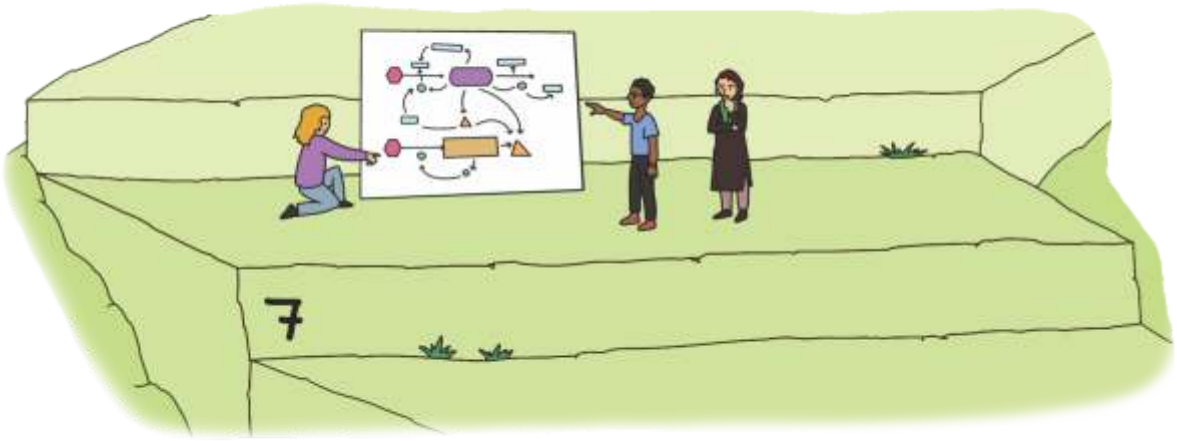
- Reflect on what is learnt thus far, summarizing the activity
- Ask the group to think about and share further questions about the system.
- The answers to these further leading questions may be discussed in the next (or one or more of the next steps).

5. Examples

Step 7 in the Jeans example
Step 7 in the Chips example

Further leading questions

- How can leverage points be used to achieve an intended behaviour of the system?
- Is it possible to make different types of intervention/s?
- Who decides that an intervention should be made, and with what aim?



STEP 8

IDENTIFY POTENTIAL TYPES OF INTERVENTIONS

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, **identify** potential points of, and **types of interventions,** generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What does this mean?

In this step, learners understand that systems can be changed in different ways, according to the intention and the manner in which the leverage is applied. One goal of enhancing systems understanding is to enable us to make decisions and take actions on a sound base of knowledge.

People intervene in systems without adequate knowledge, which result in impacts that were neither anticipated nor imagined. For example, the pumping of carbon dioxide into the atmosphere from the beginning of the industrial revolution was an unknown intervention in the earth's climate system, which has had unanticipated impacts.

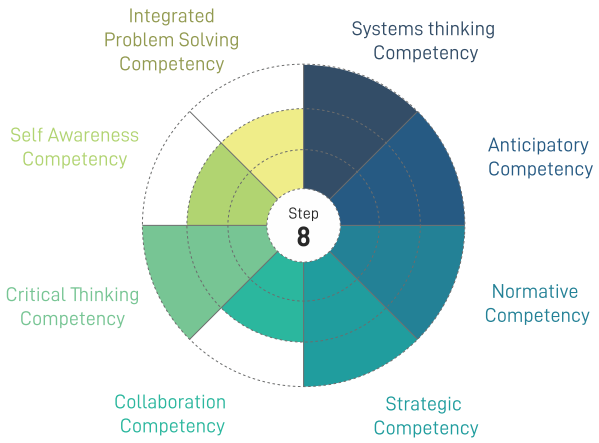
On the other hand, when a system is well-understood, it may be possible to design interventions with specific elements of the system, that cause a specific change in the overall behaviour of the system and result in an intended output or impact.

2. What is the aim?

To enable learners to:

- Understand that humans continuously intervene in many subsystems of the Earth system, and therefore in the global system itself,
- Understand that interventions have been and are being done, knowingly or unknowingly, and often with partial knowledge.
- Understand that systems learning enables humans to decide and act to change systems, with purpose driven by more sound knowledge.
- Use knowledge about leverage points to design and make interventions that change the functioning of systems.

Potential for Competence Enhancement in Step 8



3. Teaching approaches

In Step 7, learners understood that the systems can be changed through leverage points, for example through a paddle in a boat. In Step 8, learners take up tasks to understand that with the same leverage point, systems may be changed in different ways. For example, the paddle in a boat may be used to turn left, or turn right, or go straight ahead.

In this step, learners have to use the output of Step 7 – the identification of leverage points – and prepare a description of one or more potential interventions to transform the system.

To prepare the learners for the activities explain how the direction of movement may be changed using the example of the boat and paddle. Similarly, a situation may be changed with the

help of a leverage point. Next, engage the learners in these two activities described below.

Activity 1 - Identify similar examples, such as certain parts of vehicles, tools of different kinds, and the different ways they may be used to change the systems behaviour.

Activity 2 - Ask learners to apply their understanding of different uses of leverage points and identify two or more options to change system behaviour in their model.

Learners may try to identify leverage points for one or more of the following situations, in the chips or jeans examples:

- Change (increase or decrease) the quantum of profits of farmers.
- Change the quantum of chemical inputs in agriculture.
- Change the expenditure on jeans or chips by households.
- Change the health awareness of young people.

Learning methods

- Transfer
- Advocatus Diaboli
- Future Workshop
- Influence Matrix

4. Conclusion

- Reflect on what is learnt, either by summarizing the activity or asking learners to do so.
- Reflect on the crucial learning that systems can be changed.
- Ask the group to think about and share further questions about the system.
- The answers to these further leading questions may be discussed in the next steps.

5. Examples

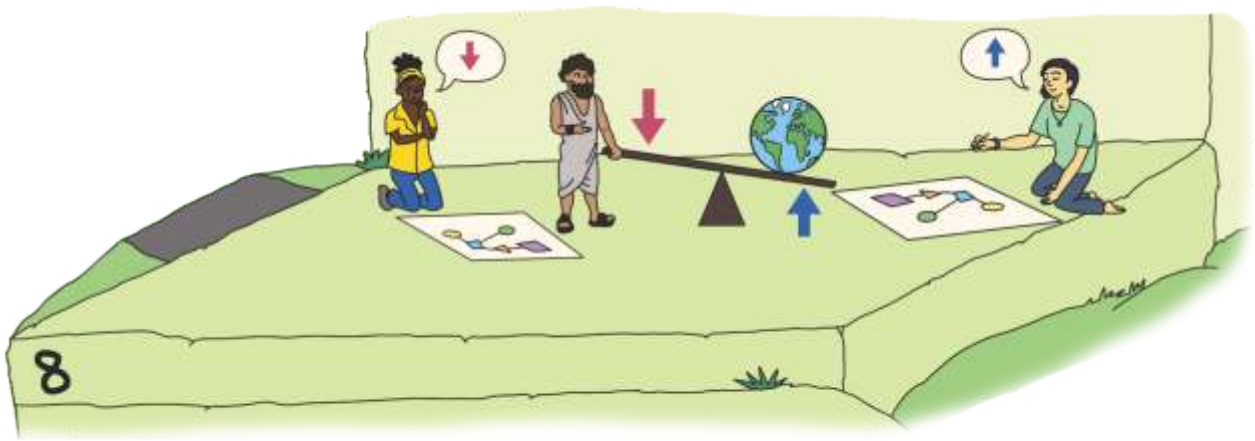
Step 8 in the Jeans example
Step 8 in the Chips example

Leverage point	Jeans	Chips
System Structure		
Add constraint on	GM Cotton	Chips with high trans-fat served in school canteen
Change Rates	Jeans bought every year	Cost of chips in school canteen
Information Flows		
Increase Buffer of	Recycled jeans	Number of days chips are consumed in a month
Add/Modify Feedback Loop	Highlight carbon footprint of each Jean	Highlight health impacts of over consumption of chips
Expand Communication Systems	Customer & Designer interactions	Interactions between students and experts and practitioners of Sustainable Food

Organising Principles		
Change rules	In favour of recycling	Rewarding students and parents who prefer homemade food (lunch boxes) in school
Enhance Organisation of the system	Encourage alternative fashion	Organise healthy food festivals in the schools
Align Shared Goal	Add environmental responsibility across supply chain	Make parents, teachers, and school management aware of the fact that giving younger generations a healthy lifestyle is their shared responsibility
Mindset		
Modify beliefs	Promote sustainable jeans	Promote sustainable food
Increase system capability to transcend paradigms	Decentralisation Shorter value chains	Enjoy eating other healthier foods, Make the impact of eating healthier foods visible to all actors in the system

Further leading questions

- Is it possible to change a system in an intended direction to enhance sustainable development?
- If yes, how may this be done?

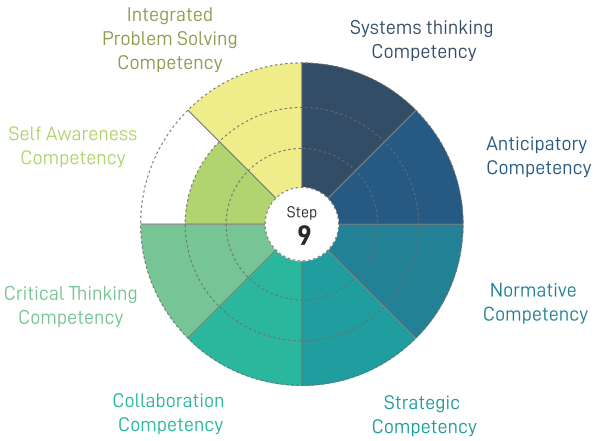


STEP 9

GENERATE OPTIONS TO ACT IN THE FRAME OF SUSTAINABLE DEVELOPMENT

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, **generate options to act,** assess their impacts **in the frame of sustainable development,** and decide whether further actions are necessary or not.

Potential for Competence Enhancement in Step 9



1. What does this mean?

In this step, learners work with their system model to change the current and anticipated unsustainable behaviour of the system, into a new behaviour in line with sustainable development goals or frameworks. In this process, learners have to take into consideration dilemmas, trade-offs, ethics, strategic thinking, and counter-intuitive actions.

2. What is the aim?

To enable learners to:

- Reflect on unsustainable situations and decide on desired futures in the frame of SD,
- Apply the understanding of leverage points and their handling, to decide the course of interventions to achieve desired future outcomes,
- Deal with potential dilemmas,
- Prepare a strategy to implement the intervention.

3. Teaching approaches

In Step 8 learners understood that with the same leverage point, systems may be changed in different ways. In this step, learners explore the possibility to change a system in the intended directions towards sustainable development.

Ask learners to:

- Look at the list of unsustainable outputs/ outcomes as identified in the analysis of the system/sub-system they chose, in Step 6.
- Imagine a sustainable future for the system they are exploring.
- Next, identify one or more leverage points to improve sustainability outcomes, and explain their choice. For example:
  - I pick ... as it is related to ... unsustainable behaviour.
  - I pick ... because other unsustainable behaviour will also be addressed if I address this one.
  - I pick ... because I can do something here, but not at another leverage point because I am not able to do so.
- Create ideas and strategies to enable the change needed for the desired sustainability outcomes in their system.

Note: Learners may choose actions that they can themselves implement. They may also choose actions to be carried out by others and may develop their strategies more theoretically.

Learning methods

- Narration and Storytelling
- Future Workshop
- Debate
- Backcasting
- Scenario Analysis
- Analysis Matrix

4. Conclusion

- Reflect on what is learnt, either summarizing the activity or asking some of the learners to do so.
- Ask the group to think about and share further questions.
- The answers to these further leading questions may be discussed in the next step.

5. Example

Step 9 in the Jeans example
Step 9 in the Chips example

Further leading questions

- Are the ideas/ strategies really improving sustainability outcomes?
- If no, then what can be done?

STEP 10

ASSESS POTENTIAL IMPACTS OF INTERVENTIONS IN THE FRAME OF SUSTAINABLE DEVELOPMENT AND DECIDE FUTURE ACTIONS

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, **assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.**

1. What does this mean?

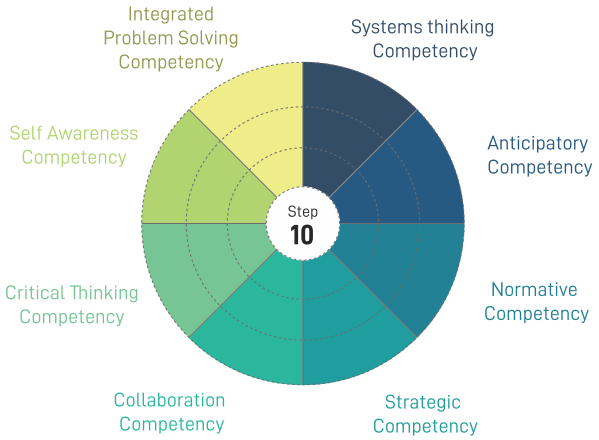
In this Step, learners analyse the decisions taken in Step 9, reflect if their intervention (related to the leverage point) and its impact on the system or subsystems, resulted in improved sustainability outcomes or whether further interventions are needed. In that case, they have to understand that they may need to review decisions taken in an earlier Step.

2. What is the aim?

To enable learners to:

- Assess whether interventions in the system resulted in improved sustainability outcomes.
- Assess whether the choice of intervention in the system was appropriate to effect improved sustainability outcomes.
- Decide if further interventions are needed.

Potential for Competence Enhancement in Step 10



3. Teaching approaches

In Step 9 learners developed strategies to change a system in intended directions of SD. In this Step, they have to check if their idea or strategy really improves sustainability outcomes, and if not, they have to go back to Step 8.

As a preparatory task, some examples of well-intended actions resulting in unintended consequences that create other problems, may be shared. (E.g., "The DDT Dilemma" in the box below.)

The DDT Dilemma

DDT is probably the most famous and controversial pesticide ever made. An estimated 1.8 million tons of this inexpensive and historically effective chemical have been produced and applied worldwide since 1940. DDT came into use to protect soldiers from insect-borne diseases such as malaria and typhus during World War II. It remains a public health tool in parts of the tropics. The heavy use of this highly persistent chemical has, however, led to widespread environmental contamination and the accumulation of DDT in humans and wildlife. Though the intention was to protect human health, the use of DDT had unintended consequences of adverse impacts on the health of human being and other species. The detrimental effects of pesticides on the environment were brought to public attention by American biologist and conservationist Rachel Carson in her 1962 book, *Silent Spring.* The book highlighted that the uncontrolled use of pesticides was harming and even killing not only animals and birds, but also humans. Its title was meant to evoke a spring season in which no bird songs could be heard, because they had all vanished because of pesticide abuse.

To think through the consequences of the interventions planned in the previous step, let groups of learners exchange their strategies (one person from the group may join the new group to explain the strategy).

The tasks for each group are:

- Imagine the application of the strategy developed by their partner group, and check if the changes planned for, would really occur.
- Is the planned strategy adequate, or will other interventions also be necessary?
- Are there any unintended consequences, and will these improve sustainability behaviour or outcomes, or worsen the situation, and how?
- Let each group present their review to their partner group.

Ask learners what could be done if the strategies developed fail or do not work as intended. Encourage them to identify which step they need to go back to in order to review and correct their strategy.

Learning methods

- Think, Pair, Share
- Debate
- Advocatus Diaboli
- Group Jigsaw
- Role play (e.g. organizing a jury)
- Analysis Matrix
- Explainer video
- Podcast

4. Conclusion

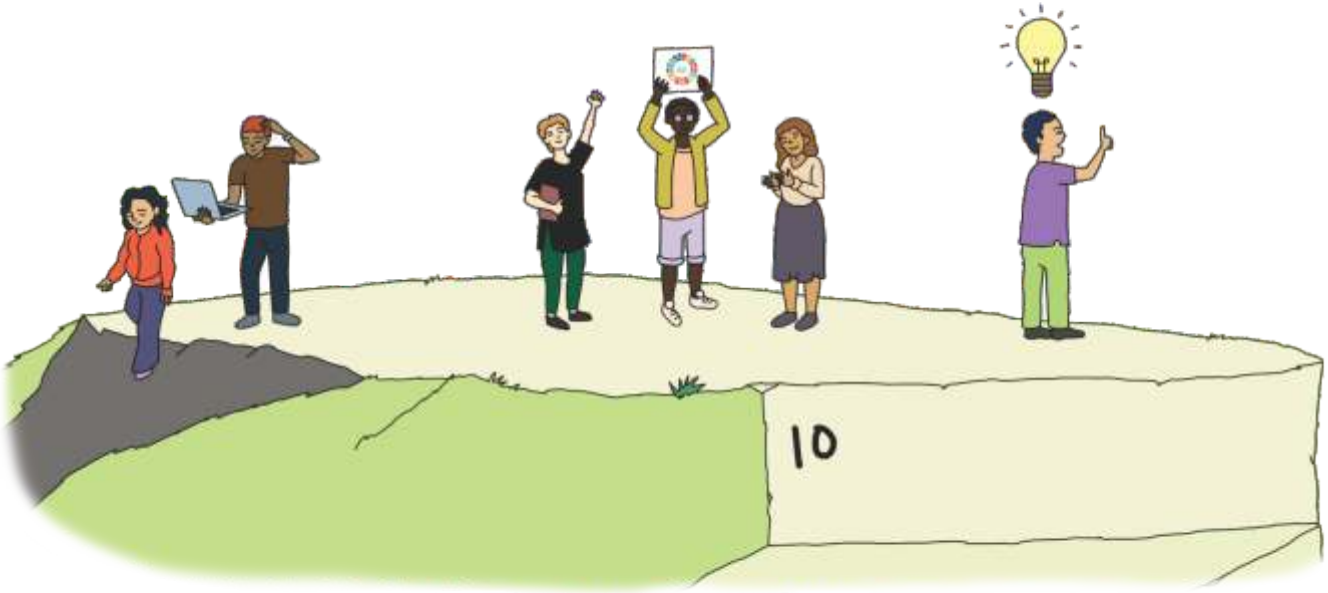
- Reflect on what has been learnt, either by summarizing the activity or asking learners to do so.
- Ask the group to think about and share further questions about the object or situation.

5. Examples

Step 10 in the Jeans example
Step 10 in the Chips example

Further leading questions

- What is the use of systems thinking to you personally?
- Can you think of some situations in your life that you could apply systems thinking to, in favour of sustainable development?



COTTON JEANS

Introduction to the Jeans Example

Since their invention in 1871 by Jacob Davis in partnership with Levi Strauss, jeans have reached almost all parts of the world and entered all walks of life. Among the global goods, they are one of the most widespread products traded for decades. Globalization of jeans has occurred not only in the use of jeans but also in the production of jeans. Already for decades, jeans are no longer just the rough and tough clothing of workers but a fashion item, worn throughout the world in all societal groups and by all generations.

Most people see their pair of jeans as something of daily use or as a fashion item. Most people do not see their pair of jeans as a part of a global production system - which it is. Therefore, we chose 'jeans' as a familiar item of everyday use to open the world of systems thinking.

The ten steps towards systems thinking use the jeans to illustrate a specific system. Thus, the course is not about cotton and jeans production but about a specific way of thinking, illustrated through the world of jeans.

Nevertheless, to explore this way of thinking, some familiarity with the basic situation about cotton and the production of jeans is needed. The status of cotton farming, and production of jeans may change from time to time. Therefore, placed here are some sources of information and regularly updated data about cotton that may be useful to understand the cotton and jeans system.

For further reading, please see:

Dagenais, Jules (2019). *Cotton: History, Properties and Uses.* Nova Science Publishers Inc.

Riello, Giorgio (2015). *Cotton: The Fabric that Made the Modern World.* Cambridge University Press.

Riello, Giorgio: Cotton: *The Fabric that Made the Modern World*. 2015

For facts and figures, please see:

Shahbandeh, M. (2021). *Cotton - statistics & facts.* Statista. https://www.statista.com/topics/1542/cotton/#dossierSummary

The World Counts: *cotton production statistics* https://www.theworldcounts.com/challenges/consumption/clothing/world-cotton-production-statistics/story

World Trade Organization (2020). *Why Cotton? Facts & Figures.* https://www.wto.org/english/tratop_e/agric_e/wcd_2020_fact_and_figures_e.pdf

Food and Agricultural Organisation (FAO) http://www.fao.org/faostat/en/#search/cotton

STEP 1
DESCRIBE A PAIR OF JEANS

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Produce a structured description of jeans, including:
  - constituent elements, such as natural and human-made, tangible and intangible,
  - numbers or quantities, if relevant, and,
  - perceptions and feelings about the jeans.
- Reflect on their knowledge about jeans production, recognize that knowledge can be enhanced by other sources, and develop the ability to seek information.

2. Teaching approaches

Ask the learners to:

- Describe their jeans or that of another fellow student in detail.
- Make a note of any questions that come to your mind in that context.
- In a plenary, ask the learners to present their descriptions.
- Share the images below (or similar ones) with the learners. What are the similarities or dissimilarities between the jeans they described and those in the pictures?
- Brainstorm with the learners to make a list of questions about jeans, the answers to which would help to enrich their own and others' descriptions.

Photos by Nicola Pape

Here are some examples:

- What are jeans made of?
- Are all jeans 100% cotton, or are some other materials used?
- What is cotton, where is it grown, and how is it processed into the cloth used for jeans?
- Is cotton blue?
- What is needed to produce jeans?
  - Who produced these jeans?
  - Were these jeans produced by one or by many people?
  - Where do the needed components come from to produce jeans?
  - What does "Made in" mean exactly?
  - How do jeans get branded, are they all made in Italy?
  - Do all necessary components come from Italy?
  - Who is behind the brand?

Learning methods

- Brainstorming
- Cinquain
- Structured Description

3. Further leading questions

- Where in Italy is cotton grown to make the jeans in Italy?
- See the learners' questions.

STEP 2

EXPRESS THE REALITY OF JEANS PRODUCTION AS A MODEL

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, **express that part of reality as a model, understand the model** as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- enrich the description of reality they created in Step 1,
- transfer this description into a model of a static situation.
- assess the quality of a model.

Source: http://pixabay.com, jeans: Nicola Pape, private

2. Teaching approaches

- How does cotton become a pair of jeans? Share these or similar images and initiate a discussion among the learners.
- Encourage the learners to review multiple sources of information, such as the following to get information for the structured description and identify elements and (inter) relationships of how the cotton becomes a pair of jeans:
  - The graphic on cotton production (provided later in this step),
  - Internet research,
  - Videos (Video content analysis method) (see Resources).
- In groups, learners may create a concept map with the information they have gathered and prepare a model of how cotton becomes jeans. For your reference, an example of a partial concept map on Jeans is presented in Figure 2 - Cotton Model.
- Next, the learners may explain their model of the cotton jeans system to the class and compare if all groups have the same information.
- Ask learners to reflect on the purpose of the cotton-jeans system. You may need to share some examples to get the learners to reflect on the different purposes of the cotton-jeans system:

  The purpose of the system of production of cotton and manufacture of jeans is to ...
  - earn a livelihood for farmers
  - profits for the jeans company
  - clothes for people, etc.

Learning methods

- Internet Research
- Video Content Analysis
- Structured Description
- Concept Mapping

Resources

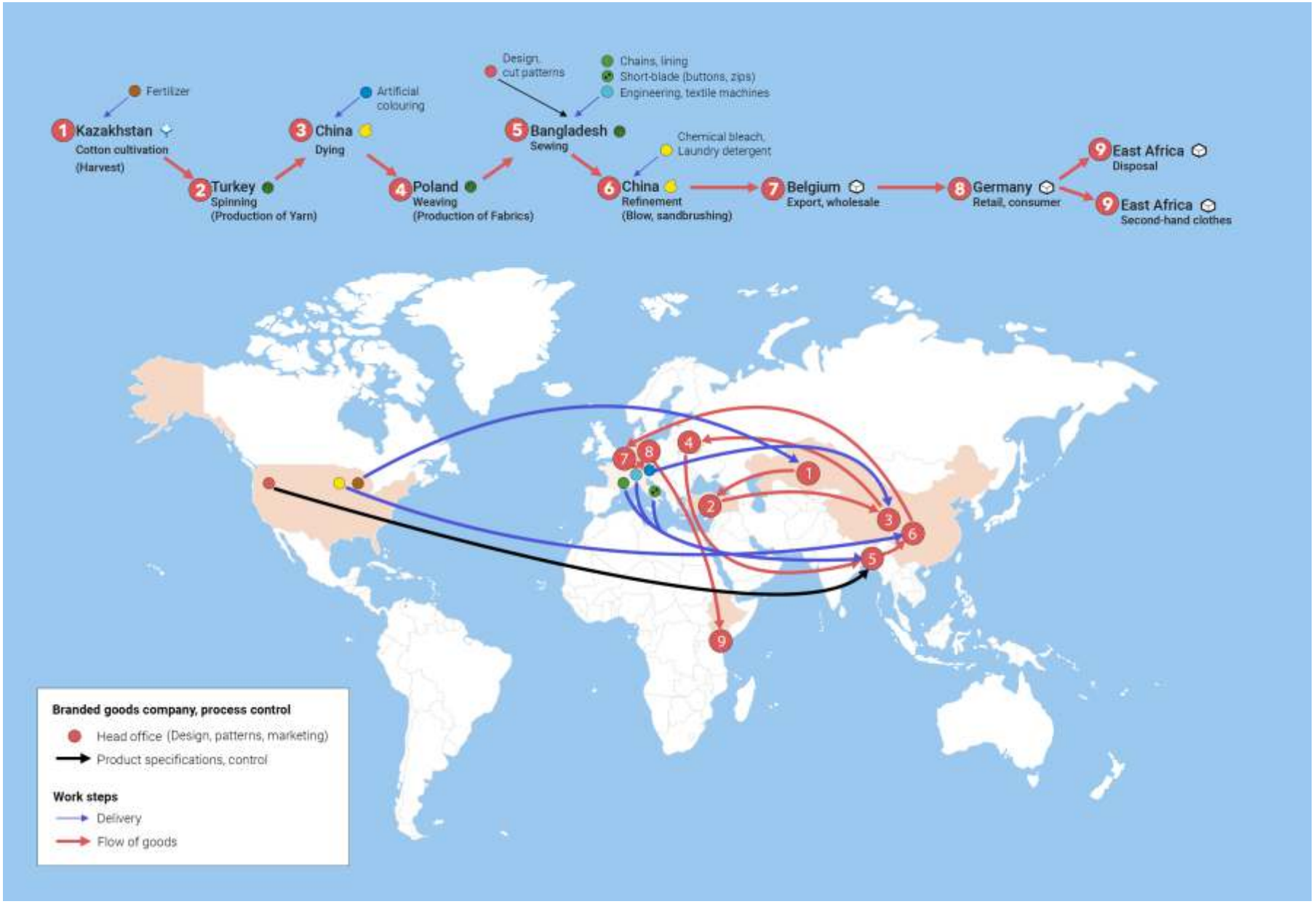
Agworld Farm Management Software. (2019, December 18). *Cotton Production: From field to factory! [Video]* YouTube. https://www.youtube.com/watch?v=jJnjFg94l3s

MosesShahrivar. (2008, July 29). *MO'CYCLE MANUFACTURING JEANS IN ITALY* www.MOCYCLE.eu.b [Video] YouTube. https://www.youtube.com/watch?v=6-fBWIG5rPI

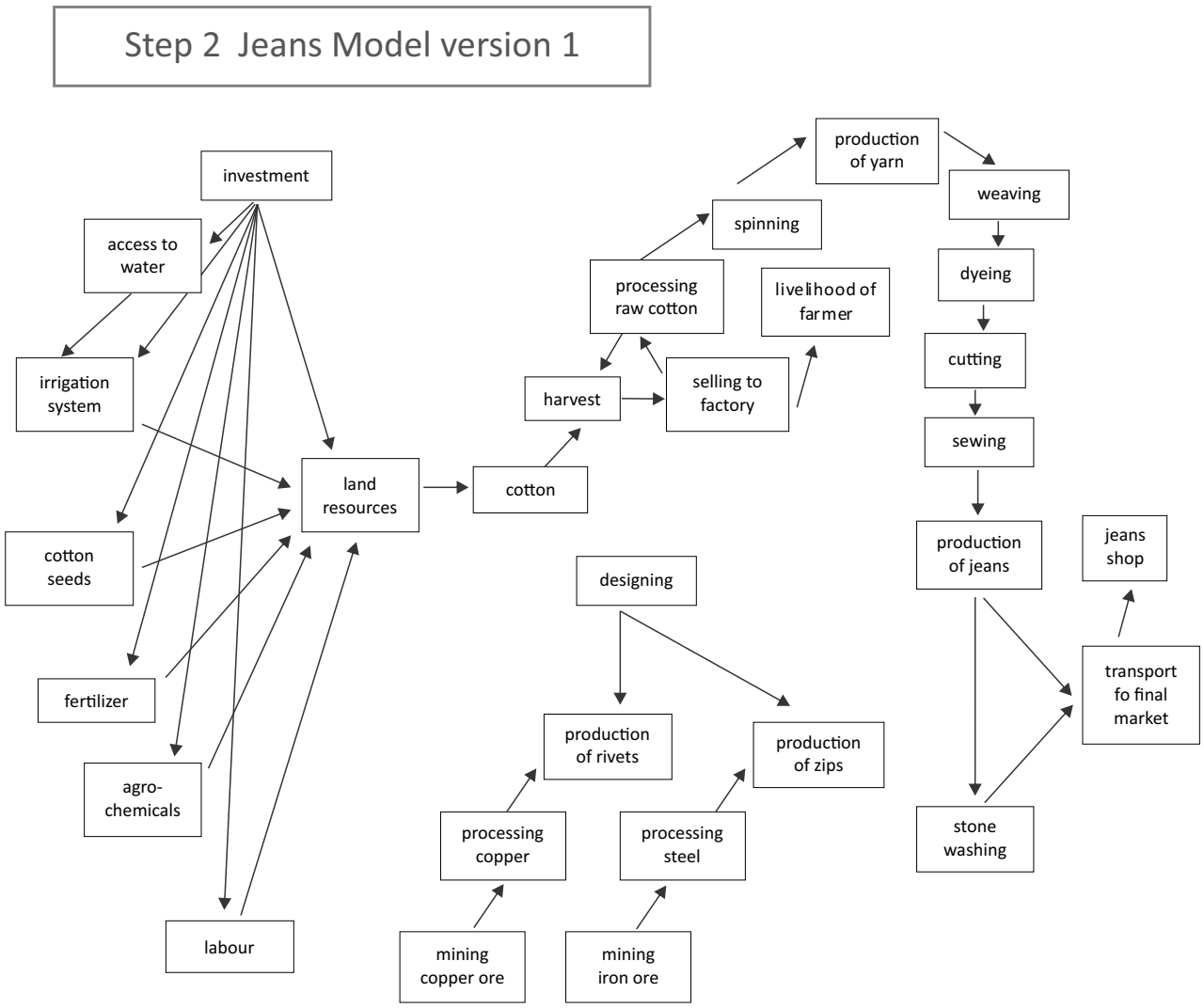
3. Further leading questions

- Does the model (concept map) you have developed correctly present the reality of how cotton is produced?
- Is the model suitable to understand a reality that may change in the next moment or sometime in the future?
- If the reality is not static, should we look for models that can also depict the dynamic nature of reality?

The global supply chain of cotton jeans



Based on Westermann Gruppe (u.d), Globale Warenketten (am Beispiel Jeans) - 978-3-14-100800-5-271-4-1 available at https://diercke.westermann.de/content/globale-warenketten-am-beispiel-jeans-978-3-14-100800-5-271-4-



An example of the cotton jeans model

Example of a learner's description

Cotton characteristics

"Cotton grows best with her feet in the water and her head in the sun!". This saying describes the climatic conditions in which cotton grows well. Semi-arid and arid areas where sufficient water resources for intense irrigation are available are ideal for growing cotton, such as Central Asia, India, Turkey, Egypt, and China's western region.

The production of 1 kg raw cotton requires 11,000 litres of water, and in some areas even more than 20,000 litres. Globally, cotton production needs 256 km^3 of water, an amount, which is enough to supply 120 Litres of water daily to each human being worldwide. 2500 litres of water are required to produce one single T-shirt.

STEP 3

UNDERSTAND THE MODEL OF JEANS PRODUCTION AS A SYSTEM

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, **understand the model as a system,** use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- understand whether the model of jeans production is a system and if it is a system, it whether is static or dynamic
- become familiar with and use the specific vocabulary of systems approaches (such as element, interrelationship, function, system, dynamism),
- identify elements such as actors or factors in the production of jeans,
- identify interrelationships among elements in the production of jeans, such as processes, communications, energy or information flows, cultural norms, legislations or rules,
- understand that a system has integrity (functions as a unit) and has a boundary,
- understand that a system may be nested as a 'sub-system', within another system, or even within other systems,
- list the outputs of the system/sub-systems, and
- understand that co-functioning elements and interrelationships cause dynamism of systems.

2. Teaching approaches

- First, ask the learners to conduct the generic Moving Game.
- Next, engage the learners in making cards after a discussion and conduct the Moving Game with Cotton. This activity should help the learners understand that different elements in a system are connected to each other in dynamic relationships.
- Ask learners to review the concept map they made in the previous step and (in pairs or small groups) develop it further. They can add elements and interrelationships and prepare a series of statements that describe the system and its components.
- Discuss with the group:
  - The model is the representation of a dynamic system, where the elements are interrelated.
  - When the dynamics of one or more elements changes or stops altogether, it affects the other elements in turn. Thus, the primary learning point for learners in this activity is to understand that the elements in the system to produce a pair of jeans are interrelated.
- You can help sharpen the learners' competence to make and communicate logical arguments by getting them to explain the dynamic behaviour of the system. The learners may present their explanations through interviews, Explainer Videos or podcasts.
- Encourage the learners to describe the production of jeans, as depicted in the model they have developed. They may use a technique such as Explainer Videos.
- Ask four learners to prepare a presentation on their model and ask some other learners to interview them. The interviewing learners should try to identify the elements in the presented system and the interrelationships between them.

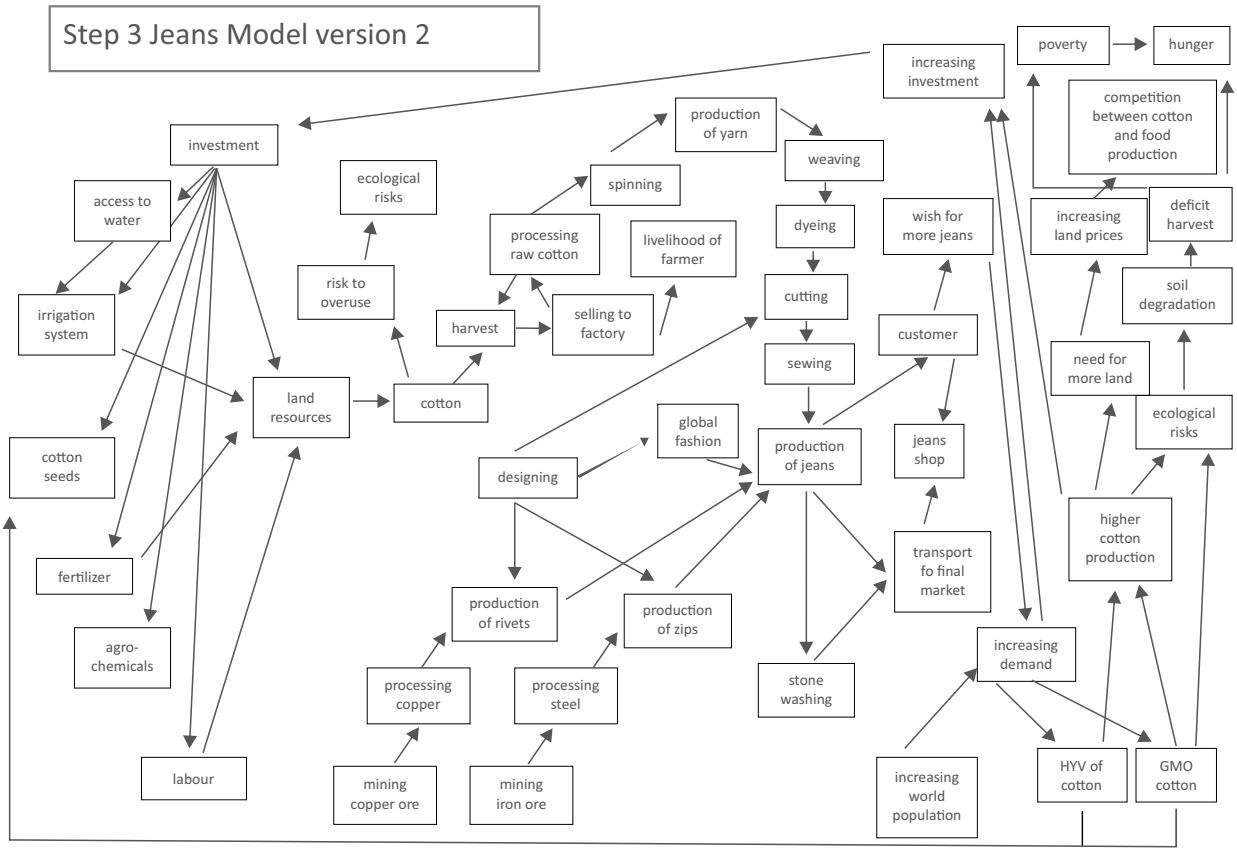
Examples of the interviewers' line of questions to explore the model:

- One interviewer wants to know how the production of jeans works in detail.
- Another wants to check on the structure of the model.
- Some ask about the origin of stonewash jeans.
- Another interviewer may ask about the colours of jeans.
- Another wants to check on the structure of the model.
- How does pricing affect the popularity of the brands?

Tip: the learners can present their model, interconnecting the words and symbols, or just using symbols that represent the elements of the system. For guidance, see the worksheet From reality to model.

Learning methods

- Moving Game and its variation for cotton jeans system
- Concept Mapping
- Understanding Causation
- Explainer Video
- Interviews
- Podcast



Model of the Cotton Jeans System

3. Further leading questions

- Is the availability of the water needed for cotton production assured?
- Are there water shortages due to cotton cultivation?
- Are there ecological impacts due to agrochemicals used in cotton cultivation?
- Does cotton cultivation and processing provide an adequcte income for labourers?
- Who decides the purpose or function of a system?

STEP 4

USE THE MODEL OF JEANS PRODUCTION TO EXPLAIN THE BEHAVIOUR OF THE SYSTEM

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, **use the model to explain the behaviour of the system,** anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

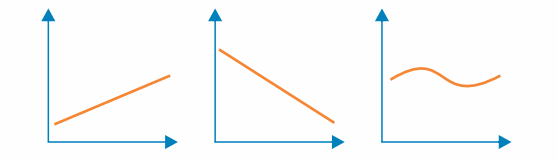
1. What is the aim?

To enable learners to explain the past behaviour over time of the system of the chosen topic.

2. Teaching Approaches

- Share again the Jeans model representing the production and use of cotton, as depicted in Figure 3 (in Step 3). The system is geared to continue to produce more cotton.
  To cross-check this, see the video Top Cotton Producing Countries from 1960 to 2019

- Introduce the concept of Behaviour over Time and that it can be plotted as a graph. Ask the learners, to describe the trend of production of cotton over the last few decades. Which graph matches this trend?



- Use the method Think, Pair, Share to involve the learners in preparing descriptions of the system's past behaviour. They should discuss any one of the following questions and, through their answers, try to develop an understanding of the behaviour of the system in the past:
  - Have jeans always been as popular as today?
  - What has changed from the last century in the ways or the reasons that people wear jeans today?

- Ask the learners to select of few elements of their interest from the cotton jeans system. They should try to find out more about the elements and its behaviour overtime and draw graphs representing these changes over time. They may discuss, for example, the trends of:
  - Farmland acreage used for cotton farming
  - Use of fertilizers in cotton farming
  - Use of genetically modified varieties of cotton

Learning methods

- Behaviour over Time Graphs
- Think, Pair, Share

Resources

ShuboTube (2020, March 24). *Top Cotton Producing Countries from 1960 to 2019 | Bar Chart Race | Shubotube.* [Video]. YouTube. https://www.youtube.com/watch?v=naY1xBwk_rk

3. Further leading questions

- What will happen or what situation may arise in the future if people and different actors in the Jeans system continue to behave as they have done over the last several years? Encourage the learners to think about this question with reference to specific elements, such as soil quality, or farmers' incomes, or waste materials in the environment.

- How do the current systems of production (of raw materials) and consumption (or use of jeans) affect and keep up with the demand for jeans and the evolution of fashion? How do different actors deal with the availability of land for cultivation? Is there a scarcity of cultivable land?
- What is the environmental impact of the system of cotton and jeans production and use?
- How is the social status of people influenced by their level of consumption?

STEP 5

USE THE MODEL OF JEANS PRODUCTION TO ANTICIPATE THE FUTURE BEHAVIOUR OF THE SYSTEM

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, **anticipate the behaviour of the system,** and evaluate its impacts on sustainable development, identify potential points of, and types-of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- recognize that it may be possible to anticipate potential futures of the jeans production using a systems model, and use systems models to make projections about jeans production.

2. Teaching Approaches

- In pairs, learners, the should use internet research to answer the following questions:
  - How much water do we use to take a 10-minute shower?
  - How much water is needed to produce a pair of jeans?
  - How many showers can we take with the amount of water used to produce a single pair of jeans (considering a shower of 10 minutes)?
  - How many jeans are produced every year?

- Ask the learners to think about the future of cotton and jeans production. What in their view would be the worst- and the best-case scenarios in the future?

- Use the Scenario Analysis method to engage learners in predicting the future behaviour of the system. The question for the scenario analysis is How much water will be needed to produce the estimated quantity of jeans in a year under two different scenarios?

  Scenario 1 - Calculate the amount of water used and the pairs of jeans produced per year if we increase the production by 50%.

  Scenario 2 - Calculate the amount of water used and the pairs of jeans produced per year if we decrease the production by 50%.

Questions to think about:

- How much freshwater is available in your country in a year?
- Is the amount of fresh water available in the country adequate for jeans production? Consider jeans production under the two scenarios of water availability.
- Ask the learners to continue the groups from Step 4 and to review the graphs they drew representing the behaviour with regard to the selected elements (e.g.fertilizer, income, soil quality, cotton production etc). They should draw a graph behaviour of the elements they selected. to represent the projected.

Learning methods

- Internet Research
- Video Content Analysis
- Behaviour over Time Graphs

Resources

Levi Strauss & Co (2015). *The Lifecycle of a jean.* Available at https://www.levistrauss.com/wp-content/uploads/2015/03/Full-LCA-Results-Deck-FINAL.pdf

Textile News, Apparel News, RMG News & Articles (2019, October 13). *Life Cycle of a Denim Jeans.* Available at https://textilefocus.com/life-cycle-denim-jeans/

RiverBlue (2018, January 5). *RiverBlue.* [Video] https://riverbluethemovie.eco/

3. Further leading questions

- What is the use of looking into the future (with a systems model)?
- Having anticipated future situations with the help of systems analysis, can you also understand whether these will be desirable or undesirable situations? Is that the future you want?
- Can human beings change the behaviour of systems?

Example of Scenario Analysis of water for jeans

Present Situation

1. Ask the learners to form pairs. Next, the class should use Internet Research to answer the following questions related to the **present situation:**

2. How much water do we use to take a 10-minute shower?
   About 10 to 20 litres per minute, on average.
   The water use depends on the type of shower and the source.

3. How much water is needed to produce a pair of jeans?
   An average of 6,840 litres is needed to produce a pair of jeans.

4. How many showers can we take with the amount of water used to produce a single pair of jeans (taking into consideration an average shower of 10 minutes)?
   6,840/ 100 litres = 68.4 (Two months)
   6,840/ 150 litres =45.6 (1 and a half month)
   6,840/ 200 litres = 34.2 (1 month and almost a week)

   10 litres per minute x 10 minutes = 100
   15 litres per minute x 10 minutes = 150
   20 litres per minute x 10 minutes = 200

5. How many jeans are produced every year?
   Comprehensive information about the total number of jeans produced every year is not available.
   You may draw the learners' attention to how complicated it is to really know what the industry is producing.
   According to the website '30 Fascinating Facts About Jeans & Denim', about 450 million pairs are sold in America annually.
   (See "The Fact Shop" resource mentioned below).

6. Based on the previous question, how much water is used to produce the number of jeans sold in USA every year?
   450 000 000 x 6,840 = 3,078,000,000,000 litres of water.

7. Ask the learners to watch the trailer of the movie RiverBlue. trailer of the movie RiverBlue. Ask the learners to take note of the amount of water used in the industry every year.
   28 trillion litres of water.

8. What percentage of the total water used in the industry do the jeans sold in USA represent?
   28,000,000,000,000 = 100% of the water used in the industry
   3,078,000,000,000 = water used to produce the jeans sold in USA every year

   (3,078,000,000,000 / 28,000,000,000,000) x 100 = 10.99%

Resources

Lizzie Robinson (u.d.). *30 Fascinating Facts About Jeans & Denim* (point 13). The Fact Shop. Available at https://www.thefactshop.com/fashion-facts/denim-jeans-facts#:~:text=Around%207.5%20billion%20feet%20of

Water Docs (2017, February 2). *Trailer for RiverBlue.* [Video]. YouTube. https://www.youtube.com/watch?v=pfPMeMGbrj4

Example of a Future Scenario

Using the method Scenario Analysis, learners can calculate the worst and the best scenario in the future. What are the best and the worst-case scenarios for jeans production? Learners may give a range of answers. Let us assume 50% increase and 50% decrease as two different scenarios.

1. Calculate the pair of jeans per year if we increase the production of jeans by 50% and the amount of water required for that number of jeans.

   Considering that 450 million pairs of jeans are sold in America every year,
   50% of 450 million = 225 million pairs of jeans
   675 million pairs of jeans
   675,000,000 x 6840 litres = 4,617,000,000,000 litres of water

2. Calculate the pair of jeans per year if we decrease the production of jeans by 50% and the amount of water required for that number of jeans.
   Considering that 450 million pairs of jeans are sold in America every year
   50% of 450 million = 225 million pairs of jeans
   225,000,000 x 6840 litres = 1,539,000,000,000

3. How much freshwater is available in your country per year?
   Taking Mexico as an example, the freshwater available in a year is
   471 000 000 000m^3

4. Is the amount of fresh water available in your country adequate for jeans production? Take into consideration the two scenarios

   4,617,000,000,000 - 100
   471 000 000 000 - x
   x = 10.20% (of the production)

   1,539,000,000,000 - 100
   471 000 000 000 - x
   x= 30.60% (of the production)

   In both scenarios, the amount of water available in Mexico is not enough for more than 10-30% of the production in a year.

   The learners can reflect on the possibility that it would require between 3 and 10 times the total freshwater in Mexico to meet the water needs for one year of jeans production for the US.

   Note that this example uses the number of jeans sold in USA and not the total production of jeans in the world.

Resources

VISIÓN GENERAL DEL AGUA EN MÉXICO (Overview of water in Mexico). Available at https://agua.org.mx/cuanta-agua-tiene-mexico/

STEP 6

EVALUATE THE SYSTEM BEHAVIOUR USING THE FRAME OF SUSTAINABLE DEVELOPMENT

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and **evaluate its impacts on sustainable development,** identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Gain knowledge about different approaches to measure development such as Gross Domestic Product (GDP), Human Development Index (HDI), Ecological Footprint and 2030 Agenda
- Understand which measuring system is appropriate to track sustainable development of a state or society.
- Assess different aspects of the cotton and jeans production system as sustainable or unsustainable.
- Evaluate whether the modelled system of cotton production and the jeans economy are contributing to the sustainable development process of society or not.
- Evaluate the current and future behaviour of selected parameters for their impact on sustainable development.

2. Teaching approaches

Note for the facilitator: This step is quite ambitious since the learners have to become familiar with the concepts of measuring wealth, development and sustainability, decide on the appropriate concept and adapt that to evaluate the contribution to sustainable development (or otherwise) from the contemporary cotton and jeans production systems. Therefore, it may be helpful if you conduct some preparatory activities around sustainable development before adapting this to the Jeans systems context.

Part 1 – Introducing Sustainable Development

- **What is sustainable development?**
  - The learning method "Indicator Eggs"engages leaners in discussing short case studies to understand human well-being and environmental quality as part of the foundations of sustainable development.
  - Information sheet What is Sustainable Development introduces a joint consideration of the Ecological Footprint and Human Development Index, as two dimensions of sustainable development.
  - Worksheet Measuring Development introduces different approaches such as the GDP, HDI and the 2030 Agenda.
  - You may also ask learners to view and analyse videos on sustainable development (see "Resources", below).

- **How to measure (sustainable) development?**
  - Use the Worksheet SDG Analysis Matrix to identify a suitable key to measure development and sustainable development.
  - Study the four suggestions to measure (sustainable) development.
  - Fill the Analysis Matrix and find your individual rating.

- **What is the aim of the 2030 Agenda? Match pictures with SDGs.**
  - Select and print out one or more sets of photos of a range of human activities from the pool of photos available at the photobank (see the web link in Resources, below)
  - Distribute the selected photos on the floor.
  - Invite a group of two learners to identify pairs of pictures, which are linked to selected SDG and representing either a valuable contribution or a counterproductive contribution to the aim of the SDG.

- Invite each group to share their discussions and reflections and to present the final results of their matchings.

Note: You may want to add or choose other photos from your own photo pool or resources on the internet. Pexels and Pixabay are two possible sources of photos

Part 2 – Sustainability of the Jeans system

Building on Part 1, the tasks below would help learners apply their understanding about sustainable development to the Jeans System.

What is sustainable and what is not sustainable?

- Work with a partner and decide which activities are sustainable and which are unsustainable by using the Worksheet on Cotton: Sustainable or Unsustainable
- Give reasons for your decisions.
- Name up to four more activities that can be deemed more or less sustainable or unsustainable.
- Compare your results with your partner and discuss.

Is contemporary cotton and jeans production contributing to the SDGs?

- Use the Worksheet SDG Analysis Matrix.
- Analyse which elements in the Jean systems contribute to a specific SDG or does not match with the SD goals.
- Write your conclusion in column one and two.
- Identify dilemmas which might emerge by trying to reach one SDG and have negative effects on another.

Learning methods

- Role Play
- Content Analysis Video
- Explainer Video
- Analysis Matrix

Resources

The Story of Stuff Project (2009, April 23). *The Story of Stuff.* [Video]. YouTube https://www.youtube.com/watch?v=9GorqroigqM

United Nations Development Programme (UNDP) (2015, September 25). *Transitioning from the MDGs to the SDGs.* [Video] YouTube https://www.youtube.com/watch?v=5_hLuEui6ww

For photobanks, visit

Pexels at https://www.pexels.com/

Pixabay at https://pixabay.com/

A collection is provided at https://www.ceeindia.org/systemsthinking/resources/

Information sheets

What is Sustainable Development?

Worksheets

- Measuring Development
- SDG Analysis Matrix
- Cotton: Sustainable or Unsustainable

3. Further leading questions

- Is it possible to change a system?
- How can I change the contemporary Jeans system towards more sustainability?

Example of a filled-in worksheet Cotton: Sustainable or Unsustainable
Here is an example of the worksheet "Cotton: Sustainable or Unsustainable", filled in for your reference. The version that you can share or photocopy for the learners is provided in the Worksheets section with the first and third columns left blank.

Cotton: Sustainable or Unsustainable		
Sustainable	Activity	Unsustainable
- Increase in farmers' income - Likely increase of income for the rural poor	The water supply is increased annually. to irrigate the enlarged cotton fields,	- Too much water might be taken out of a fragile ecosystem of a semi-arid region with destructive consequences for regional flora and fauna.
- Might improve the livelihood of rural poor with positive consequences concerning nutrition, health, education and others.	The fact that the cotton production industry will grow might create even more jobs than today in this economic sector.	- An increasing cotton industry needs more cotton production. More agricultural land will be used for cotton production with a trend towards monoculture and all its negative ecological consequences, especially related to degradation of soil. - Likely increase in use of agrochemicals, higher costs and negative ecological impacts.
- Economic success - Higher income - Better livelihood	Modern cotton production depends on the use of specific seeds in combination with fertilizers.	- Risk of non-biodegradable substances in the ecosystem with unknown consequences.
- Less negative ecological impact on soils and adjacent natural areas - Healthier products - Possibly higher prices - If the global market accepts higher prices for organic cotton, the farmers will have a remarkable improvement of their livelihood.	Production of organic cotton will increase in the next 10 years.	- Likely smaller production rate and less income with consequences for economic and social issues of the farmers household. - An expanding cotton industry needs more cotton production. More agricultural land will be used for cotton production with a trend towards monoculture and all its negative ecological consequences, especially related to degradation of soil.
- Greater economic success with positive consequences for farmers' livelihood.	Huge monoculture production of cotton weakens the soil fertility which leads to an increasing use of agro-chemicals.	- Clear unsustainable impact of this agricultural model.
- Easier working conditions for farmers and laborers. - Better health.	Increasing use of technology leads to improved workers conditions.	- Loss of income possibilities. - Increase in poverty.

- Greater economic success with positive consequences for farmers' livelihood.	The Future need of cotton can only be satisfied with GMO cotton.	- Risk of human - made non-biodegradable material in the ecosystem with unknown consequences.
- Easier working conditions for farmers and laborers. - Better health.	Increasing use of agro-technology saves money and lowers the expenses for the producer.	- Loss of income possibilities. - Increasing poverty.
- Increasing income possibilities with positive consequences on the economic and social dimensions of development.	Cotton exports improve the economic situation of countries like India and strengthen their social development.	- Might cause dependencies on a few market products. - Uncontrolled risks of socio-economic development.
- Possibly higher prices - If the global market accepts higher prices for organic cotton, farmers will have a remarkable improvement of their livelihood.	Fairtrade cotton offers better income and living conditions for small scale farmers and laborers.	

STEP 7

IDENTIFY POTENTIAL POINTS OF INTERVENTION IN THE JEANS SYSTEM

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- understand what a leverage point is in the context of a system,
- understand there may be different leverage points with different functions in a system, and
- apply the understanding about leverage points to the system of the chosen topic to effect change.

2. Teaching approaches

- To help learners understand the concept of a leverage point in a system, you may present the video "[Rush] - Niki Lauda meets his wife"
- Facilitate a discussion among the learners to identify different leverage point(s) in the story. (These include for example: the gear stick, attraction between people, skill of the driver, capacity of the engine).
  If it is not possible to use this video, learners may just discuss how the speed of a moving vehicle, say a bicycle, a car or a boat can be controlled. For example, in a car, the gear stick can be understood as a point of intervention. In a boat, it is the paddle. Are there other points of intervention as well? (E.g., the accelerator, the brake).
- Next, help the learners to transfer their understanding of a leverage point to the cotton and jeans systems. For this, they may work in groups of four and use the concept maps they developed in previous steps, or the concept map provided in Figure 4 Model of the Cotton Jean system
- Learners should identify such components in the Cotton Jeans system that influence the behaviour of other elements and the outputs of the system. These identified points may be leverage points.
- Finally, the learners should mark the identified leverage points in their concept map (or the provided model).

Tip: Leverage points of different effectiveness may include for example,

- The quantity of chemical fertilizers and pesticides used in cotton farms.
- Farming techniques.
- Local farmers' groups decision to shift to organic farming.
- Local farmers' groups decision to limit the acreage for cash crops.
- The source of metal for rivets (metal from mines or recycled metals).
- Design, such as to reduce materials usage and include more recycled material.
- Preference for jeans made of organic cotton and recycled metal.
- Preference for unbranded cotton trousers (instead of jeans).

Activity:

- Explain what a leverage point is in the context of a system.
- Identify leverage points in the cotton-jeans-production-system.
- Cross check the suggestions among the learners.

Learning methods

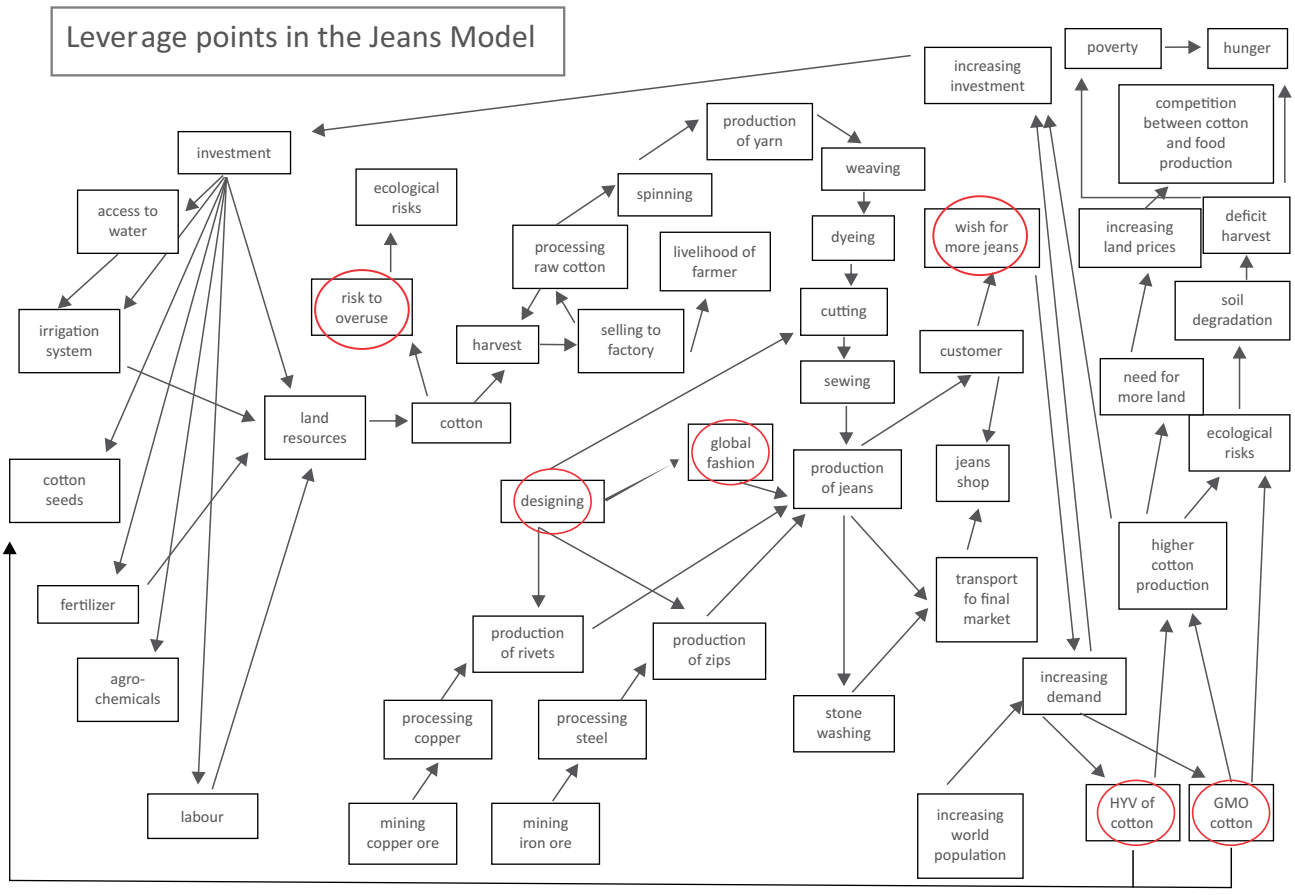
- Content Analysis a Video
- Advocatus Diaboli
- Mapping Technique, especially concept map

Resources

Walter White (2017, March 17), *[Rush] - Niki Lauda meets his wife* [Video], extract from Eaton, Andrew et al. Rush (2013). Exclusive Media Group and others. USA. Duration 4 minutes 56 seconds.
YouTube
https://www.youtube.com/watch?v=3Kl0UBS4ZaM

3. Further leading questions

- How can one use these points of intervention?
- Can I influence the behaviour of a system in general and the Cotton Production system in particular?
- Are there possibilities for different types of intervention?
- Who decides that an intervention should be made, and with what aim?



Leverage points in the Jeans model

STEP 8

IDENTIFY POTENTIAL TYPES OF INTERVENTION IN THE JEANS SYSTEM

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, **identify potential** points of, and **types of interventions,** generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not

1. What is the aim?

To enable learners to:

- Identity potential interventions to use leverage points,
- Understand that humans continuously intervene in many sub-systems of the global system, and therefore the global system itself,
- Understand that these interventions have been done, and are being done everywhere, knowingly or unknowingly, and often with partial knowledge,
- Understand that systems learning enables individuals or groups to decide and act to change systems, with purpose, and
- Use the knowledge about the points of intervention to change the functioning of systems.

2. Teaching approaches

Preparatory Activity:

- The working groups set up for Step 7 may continue.
- Explain, using examples, that different directions of change are possible at a leverage point for example:
  - A boat paddle can turn the boat in different directions, depending on how it is used, and the gear stick of a car can be used to go forward or in the reverse direction.
- Next, ask learners to identify similar examples, such as certain parts of vehicles, tools of different kinds, and the different ways they may be used to change the system behaviour.

Activity:

- Ask learners to identify different directions of change possible at the leverage points they identified in the previous step. Learners should list the actions and consequences in a table, such as the one provided in the worksheet Using the Leverage.
- Ask learners to visit the webpage titled 'The Jeans Redesign' at the Ellen Macarthur Foundation website. They may view the video, discuss the key points made and respond to the questions suggested in the worksheet Sustainable Jeans?
- Using their discussion outputs from these worksheets, learners may also produce and share a 3-minute podcast with the title: Options to change the Cotton Jeans system.

Learning methods

- Transfer
- Explainer Video
- Podcast

Worksheets

- Using the Leverage
- Sustainable Jeans?

Resources

Ellen MacArthur Foundation, *"How redesigning jeans could change the way we think about the fashion industry"* webpage at

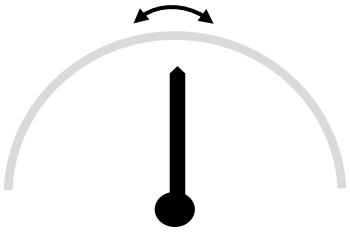
https://ellenmacarthurfoundation.org/articles/how-redesigning-jeans-could-change-the-way-we-think-about-the-fashion

Ellen MacArthur Foundation. (2020, October 22). *Clothes That Never Become Waste - The Jeans Redesign Project | The Fashion Show Episode 2.* [Video]. YouTube https://www.youtube.com/watch?v=NxlqzixxAXI&t=3s

3 Further leading questions

- Can we change the Cotton Jeans system towards more sustainable outcomes?
- Is there a possibility to change a system in an intended direction for sustainable development? If yes, how may this be done?

Example of a filled-in worksheet about using the leverage



Action/ Consequences	Leverage point	Action/ Consequences
• Increase in the acreage of farmland under cotton.	**Land resources used for cotton cultivation**	• Control of the acreage of farmland under cotton.
• Conventional mines are expanded.	**Source of metal for zips** (Using metal from mines or sourcing recycled metals)	• Recycled metal use increases.
• Business as usual continues.	**Soil degradation/ management**	• Sustainable soil management technique are adopted.
• New designs are developed frequently, promoting conventionally manufactured jeans with conventional input materials	**Desire for jeans** "Ethical jeans" (e.g. made from organic cotton and recycled metal) or "regular jeans" or even a preference for unbranded plain cotton trousers)	• Designs and brands that promote organic cotton, recycled metal, fair trade are developed.

STEP 9

GENERATE OPTIONS TO ACT IN THE FRAME OF SUSTAINABLE DEVELOPMENT

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Reflect on unsustainable situations and decide on desired sustainable futures for jeans production,
- Apply their understanding of leverage points and different options of using such leverage in a system, to decide the nature of interventions to achieve desired future outcomes,
- Deal with potential dilemmas, and
- Prepare (and possibly carry out) a strategy to implement the intervention.

2. Teaching approaches

In Step 8 learners understood that with the same leverage point, the Cotton Jeans system may be changed in different ways. In this Step, learners decide on an option for using the leverage they have identified to achieve a more sustainable cotton and jeans production system.

For this, ask the learners to:

- Form working groups of up to four members.
- Look at the list of unsustainable outputs and outcomes as identified in the analysis of the Cotton Jeans system they conducted in Step 6 Worksheet Sustainable or Unsustainable.
- Imagine a sustainable future for cotton and jeans production through a Future Workshop.
- Get back to their identification of leverage points (in Step 7) and the choices to use them (Step 8) to improve sustainability outcomes and
- Create and present a strategy to enable the change needed for an intended sustainable cotton system.

Learning methods

- Future Workshop
- Debate
- Scenario Analysis
- (SDG) Analysis Matrix
- Narration and Storytelling

3. Further leading questions

- Will the decided strategy really improve sustainability outcomes concerning cotton and jeans production?
- What is to be done if the proposed strategy does not work to improve sustainability?

STEP 10

ASSESS POTENTIAL IMPACTS OF INTERVENTIONS IN THE FRAME OF SUSTAINABLE DEVELOPMENT AND DECIDE FUTURE ACTIONS

Systems thinking is the ability to describe and/ or visualize a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, **assess** their **impacts in the frame of sustainable development, and decide whether further actions are necessary or not.**

1. What is the aim?

To enable learners to:

- Assess whether proposed interventions in the system lead to sustainability.
- Assess whether the choice of intervention in the system was appropriate and led to improved sustainability and
- Decide whether further interventions are needed.

2. Teaching approaches

In Step 9 learners developed strategies to change a system in intended directions of sustainable development. In this Step, they must assess whether their ideas or strategies can really improve sustainability outcomes.If not, they must go back to Step 8 or even Step 6 and re-think and re-plan the interventions.

As a preparatory task, share some examples of well-intended actions resulting in unintended consequences that create other problems. Learners may themselves conduct an internet search on the term 'unintended consequences' and share the examples they find most interesting.

Next, let learners' groups work together (such as by using the Group Jigsaw method) and present their strategies to each other. The other groups should provide feedback to the presenting group on the effects and consequences they expect of the strategies and interventions.

To guarantee that adequate information flows, one person from the original group should be part of the new group to explain the strategy.

The task for each group is to imagine the application of the strategy developed by their partner group, and

- Check if the changes planned would contribute to the SDGs? For this, use the SDG Analysis Matrix.
- Is the planned strategy adequate, or will further interventions be necessary?
- Are there any unintended consequences, and do these improve sustainability behaviour or outcomes or worsen the situation, and how? Use the SDG Analysis Matrix for this task again.
- Let each group present their review to their partner group.

Ask the learners what to do if the strategies developed fail or may not work as intended. Encourage the learners to identify which step they need to go back to in order to review and correct their strategy.

Learning methods

- Group Jigsaw
- Role Play (for example organizing a jury)
- (SDG) Analysis Matrix
- Think, Pair, Share
- Debate
- Advocatus Diaboli

3. Further leading questions

- What is the use of systems thinking to you personally?
- Can you think of some situations in your life where you could apply systems thinking tin strengthen sustainable development?

POTATO CHIPS

Introduction to the Potato Chips example

Why did we choose potato chips?

We decided to use the potato chips as an example for systems thinking because we want to address a topic that pertains to a tangible, familiar object and relevant to the learners' daily lives. We also realised that in the four countries represented in the ESD Expert Net (South Africa, India, Mexico and Germany), potato chips are a familiar component of the diet.

We think that potato chips is a relevant topic for young people worldwide as the health problems arising due to their daily diet are increasing. The demand for more, and different types of potato chips results in an impact on the environment such as due to an increase in the use of land resources etc..

Why did we choose two different ways to analyse the potato chips?

While developing the material, we realised that we could address sustainability in relation to "chips" from two different perspectives: that of the production of potato chips, and that of nutrition in relation to potato chips. The information and activities for these two perspectives are presented in different colours for easy navigation of the material: activities exploring potato chips production are in **green** and those exploring nutrition are in **yellow**.

In the beginning, these two perspectives appear to be separate systems. However, as we go deeper into exploring these aspects, we realise that these can be thought of as sub-systems that complement each other and belong to a larger system on the theme of potato chips.

You can choose one or both perspectives to work with your learners. Exploring both perspectives side by side allows you as a teacher to introduce systems thinking as an interdisciplinary approach with different subjects. Either way, you would help your learners to develop their systems thinking competence.

What can you expect of the 10 steps of potato chips?

The staircase model of developing systems thinking described in the generic Ten Steps is applied to the topic of potato chips in this section. The purpose of this example is to support you, the teacher, in developing the ability of your learners to address the complexity of reality in a creative and didactical way. Learners will understand

- how potato chips are produced,
- how the human body processes them, and
- the impact on the production and consumption of potato chips on the environment; and
- how different perspectives and disciplines help us develop a systems understanding.

The learners will different drivers of change and the direct and indirect impact of their own decisions and actions and reevaluate them considering the decisions and actions proposed by fellow learners. The Ten Steps towards Systems Thinking for Sustainable Development help users reflect on the significance and complexity of "act local, think global".

We hope you enjoy using this material as much as we enjoyed developing it.

STEP 1

DESCRIBE A (COMPLEX) PART OF THE POTATO CHIPS PACKAGE

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Produce a structured description of the potato chips package, including
  - constituent elements and their physical characteristics,
  - numbers or quantities, if relevant,
  - perceptions and feelings about potato chips, and the situations in which we eat them.
- Reflect on their knowledge about potato chips, recognise that knowledge can be enhanced by other sources, and develop the ability to seek out information.

Here are two activity suggestions on how to introduce the topic to the learner. You may use the activities to introduce the two perspectives of production of potato chips, and nutrition from potato chips.

2. Teaching approaches

Activity - We eat potato chips when....

Material

Different types of potato chips packages and pictures of different situations in which people might eat chips.

Procedure

Form four groups. To make groups, let everyone participate in a count to 4 in sequence. Everyone who has the same number forms a group.

Part 1 - Potato chips package

- Give the packages of the potato chips to the learners and ask them to observe and describe (as detailed as possible) the package and its elements.
- Learners should make a description of the elements they observed using the format of a Structured Description.

Part 2 - Pictures

- Each group will receive a copy of the collage of 'Chip Snacking Situations'.
- Based on the method Think, Pair, Share each group will describe the picture taking in consideration the following points:
  - Describe the situation in detail
  - Where is it taking place?
  - How many people?
  - What is the purpose of the picture?
  - What is the message of the picture?
- They can integrate the information in a tabular format, and once they finish the descriptions they should share the results in plenary.
- Each group has to introduce their potato chip packet and picture and their description, taking in consideration the following question: Why do we love to eat Chips in leisure time moments? Is the taste of the Chips or the social moment helping us to relax?
- The learners could reflect about what they know about the production and consumption of Chips and formulate some open questions.

Note to the facilitator

The outcome of this activity will be used as a help for the development of step 7.

Learning methods

- Structured description
- Think, Pair, Share

Activity: Taste and Guess!

Material

Different types and flavours of potato chips, plates

Procedure

- Put the plates with different types of potato chips on a table. The learners should not know which flavour or brand of chips they will taste.
- Ask the learners to taste the potato chips. Each learner should taste one type and describe the main characteristics. Ask them to list the main characteristics of the different types of chips. The learners take notes of the main points of their discussion.
- After they have tasted all the options and made notes, they may exchange information in groups of a maximum of four learners. To make groups, let everyone participate in a count to 4 in sequence. Everyone who had the same number (e.g., 3 forms a group). They can collate and present the information in a table (see the example below).
- Next, they are invited to combine the information they have gathered, think about it, and discuss their observations: What do these chips have in common? What is different? (Such as taste, smell, consistency, weight, surface, thickness, and any other aspects they can think of).
- Each group will make a description about the characteristics of the potato chips by using the format of a Structured Description. Once it is completed the learners could reflect about what they know about the production and consumption of chips and list further questions that come to their mind.

3. Further leading questions

- What are chips made of?
- What is needed to produce the chips?
- Who produced the chips?
- Were the chips produced by one or by many people?
- Where were the chips produced?
- Where do the needed components come from to produce the chips?
- What are the consequences for society and nature?
- In which conditions are they produced?
- How did the potato chips package get into the store?
- Why do we eat chips?
- How are the potato chips digested?
- How can we identify the taste of the potato chips?
- Is it healthy to eat potato chips?

Example of a structured description of a chips package

Package of a popular chips brand in Mexico

It does not look particularly attractive to the eye, but highlights the yellow colour of the packaging

Front: Looks like a shooting target in different tones of yellow, in the bullseye is the brand logo. You can see sliced potatoes all around the front. On the left down corner, we see half potato and some slices coming out. In the right upper corner, we see the nutritional stickers that warn us about the excess calories of the product. One slice of potato chips is pointed out with the information "only 3 ingredients, potato + oil + salt".

Back: The background is silver colour. On the right side at the top, we can see the nutritional facts followed by the ingredients and the commercial information. Below we see a small presentation of the company logos, followed by the barcode and finally we see three small circles with recycling information as well as a contact telephone number.

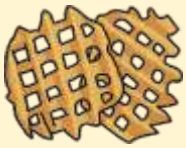
On the left side on top, we see an open sack with fresh potatoes, surrounded with some green leaves. Below this image the brand logo appears with the legend "We use organic potatoes". After the logo we see another semi-peeled potato, the peel still on the potato and a new legend says "100% potato". In bigger letters, we can read "Just the traditional taste of chips, with each crunchy bite". Below this we see a potato chip, a QR code and the social media handles of the brand.

Example of a table template to analyse chip snacking situations

	Situation 1	Situation 2	Situation 3	Situation 4
Describe the situation Where is it taking place Purpose of the picture Message of the picture				

Chip Snacking Situations

Example of a table template for tasting potato chips

Type of potato chip	Form	Smell	Taste	Image
Chip type 1	Wavy, curved, oval, yellow/white.	Salty potato, grease odour, light to salt.	Salty, crispy, leaves a slight oil sensation	
Chip type 2	Pinstripe wavy, curved, oval, embossed zig zag, orange-yellow colour.	Strong smell of cheese, cheddar cheese.	Cheese and salt, spicy with a hint of cheese.	
Chip type 3	Triangular with relief, dark yellow.	Chili and lemon, spicy with cheese.	Chili, lemon, onion, slightly spicy, cheese flavour predominates.	
Chip type 4	Spiral, braided, brownish-orange, opaque orange	Chili and cheese, slightly salty with cheese.	Spicy, cheese with a hint of salt, salty with lemon, cheese, and chili.	
Chip type 5	Waffle shaped, grid, yellow.	Flour and strong cheese, orange, the cheese predominates.	Rough, puffy texture, cheddar cheese with lemon and salt.	

STEP 2

EXPRESS A PART OF THE REALITY OF POTATO CHIPS AS A MODEL

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, **express that part of reality as a model,** understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Enrich the description of reality they created in Step 1,
- Transfer this description into a model (a simplified picture or depiction of a part of reality) of a static situation (see Information Sheet 'What is a model?'), and
- Assess the quality of a model.

2. Teaching approaches

In this step, learners are invited to:

- Identify elements and (inter)relationships from the description,
- Express the (inter)relationships between the elements, such as stocks and flows of information/ communication, energy, and physical materials.
- Identify the function or purpose of the system (which are shaped by perceptions, values, cultural aspects, rules, economic drivers, or other needs and drivers etc of people in the system), and
- Consider additional knowledge to enrich the description of the reality or situation.

Ultimately, the learners may develop and explain the structure of the model.

Activity - How is a potato chip made?

Material

Potato chips package

Procedure

- The learners review the list of the ingredients of a type of potato chip. If the learners have different flavoured chips, they can compare the differences between them.
- Create a mind map to describe how all the ingredients are brought together to manufacture a potato chips package, they must consider aspects such as: Cultivation, Production (Potatoes and no more than two other ingredients), Transportation and Marketing.
- Search for an image depicting the production of potato chips.
- Complete the mind map with the information of the model of the potato chips production.
- Once they complete the activity the learners can reflect about the information and formulate some open questions.

Ingredients

Potato, sunflower oil, seasoning, sugar, salt, tomato powder, pepper, garlic, corn starch, natural colours, natural flavouring.

Activity - What are chips made of?

Material

Potato chips package

Procedure

- The learners review the nutrition facts on a package of potato chips. They can continue with the same package of chips that they started to describe in Step 1.
- They work in groups and use the brainstorming method to list the elements related to the nutrition from potato chips and complete the following table.
- Give a hint to the learners to keep in mind the two perspectives related to nutrition: what nutrients are present in the food, and how the body takes in the nutrients.
- If the learners have different flavours, they can compare the differences between their ingredients.
- Once the learners have finished the table, they can use the information gathered to develop a mind map taking into consideration:
  - How does the human body process potato chips? How does the metabolic process work?
  - How does our body perceive flavour?
- They may search for an image about the digestive process of the nutrients and complete the mind map with the information about the digestion of nutrients.
- Once they complete the activity the learners can reflect about the information and formulate some open questions.

Learning methods

- Mapping Technique: Mind Map
- Structured Description

Information Sheet

What is a model?

Resources

Sagar Aryal (2019). *Digestion and Absorption of Carbohydrates, Proteins and Fats.* Microbe Notes. Available at https://microbenotes.com/digestion-and-absorption-of-carbohydrates-proteins-and-fats/

Fabregat A, Sidiropoulos K, Viteri G, Marin-Garcia P, Ping P, Stein L, D'Eustachio P, Hermjakob H. *Reactome diagram viewer: data structures and strategies to boost performance.*

Bioinformatics (Oxford, England). 2018 Apr;34(7) 1208-1214. doi: 10.1093/bioinformatics/btx752. PubMed PMID: 29186351. PubMed Central PMCID: PMC6030826.

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Moncel (2019). *How salt is made.* The spruce Eats. Available at https://www.thespruceeats.com/how-is-salt-made 1328618#:~:text=While%20the%20ocean%20is%20a

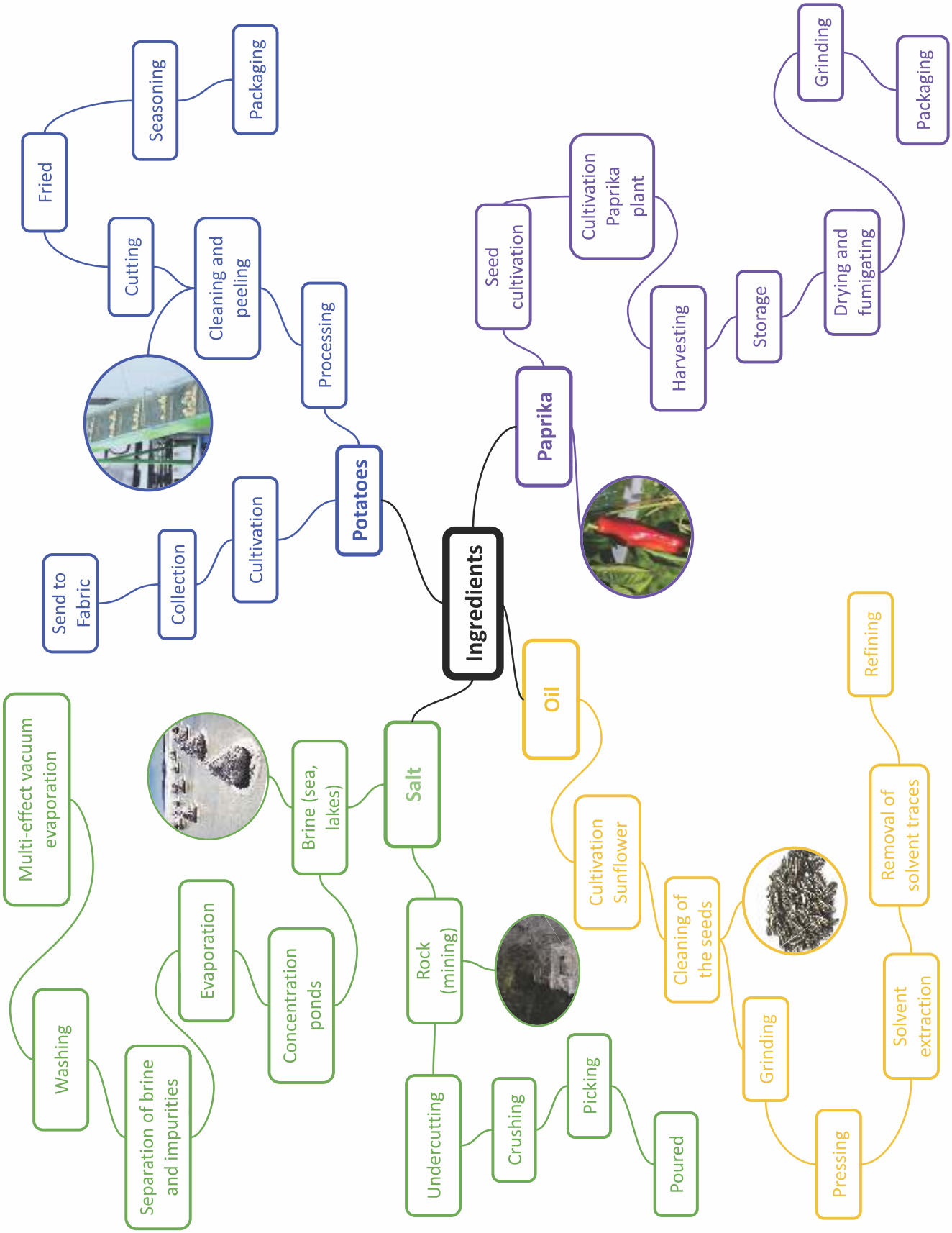
KMEC (u.d.). *Sunflower oil production.* Available at http://www.oilmillmachinery.net/sunflower-oil-production.html

Amazing Toks (2020, July 16). *How is sunflower oil produced (made)? The process of making sunflower oil.* [Video]. YouTube. https://www.youtube.com/watch?v=w7IH1ll0rqc

3. Further leading questions

- Does the model (Mind map) you developed really present the reality of how potato chips are produced?
- Does the model you developed really present the reality of how potato chips are digested by the body?
- Is the model suitable to understand a reality which may change in the next moment, or tomorrow or sometime in the future?
- If the reality is not static, should we look for models that can also depict the dynamic nature of reality?

Example of a concept map on ingredients of potato chips



Template for a table to discover a model

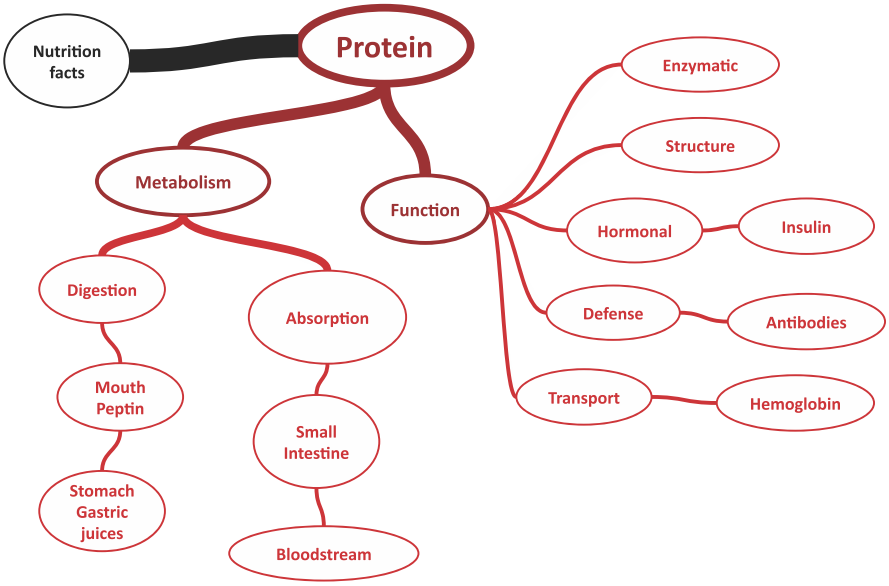
Element	Interrelationship
Mouth	Breakdown the food, connected with oesophagus
Stomach	

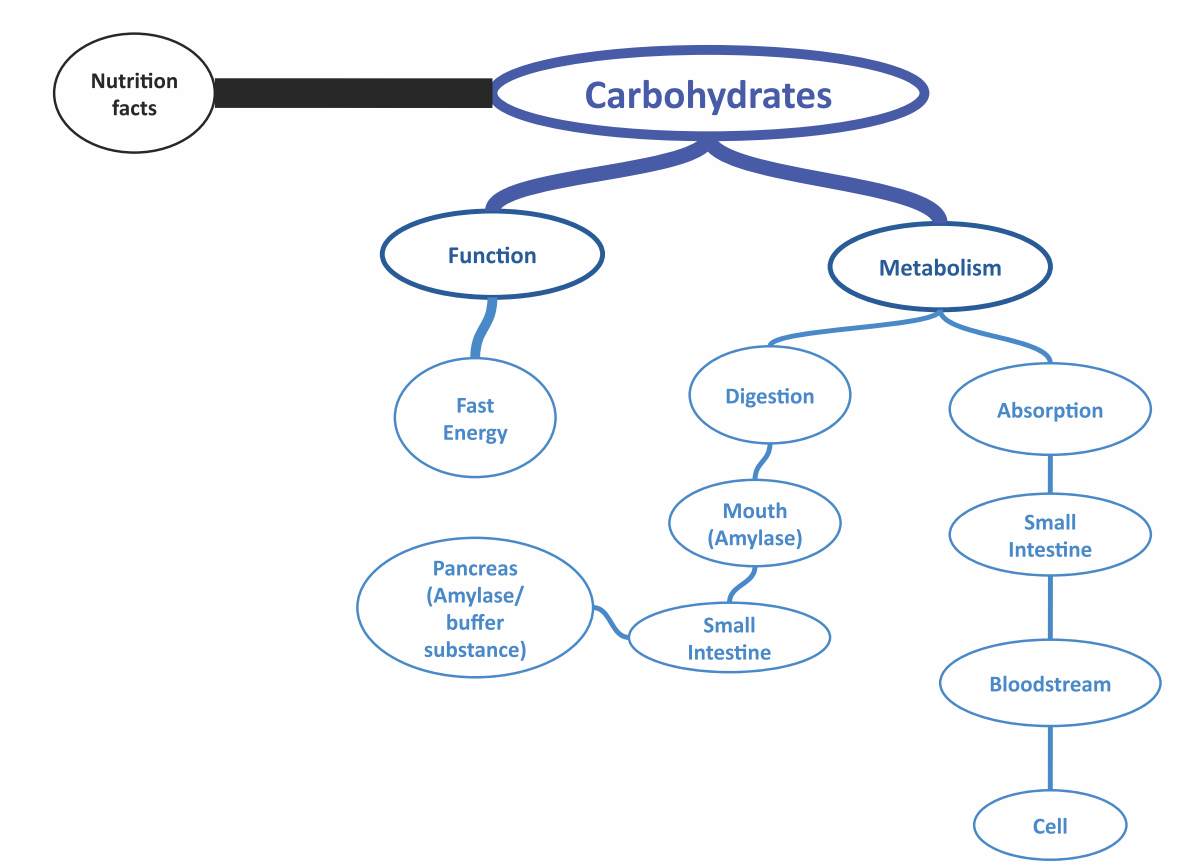
Example of a template for description of elements and interrelationships

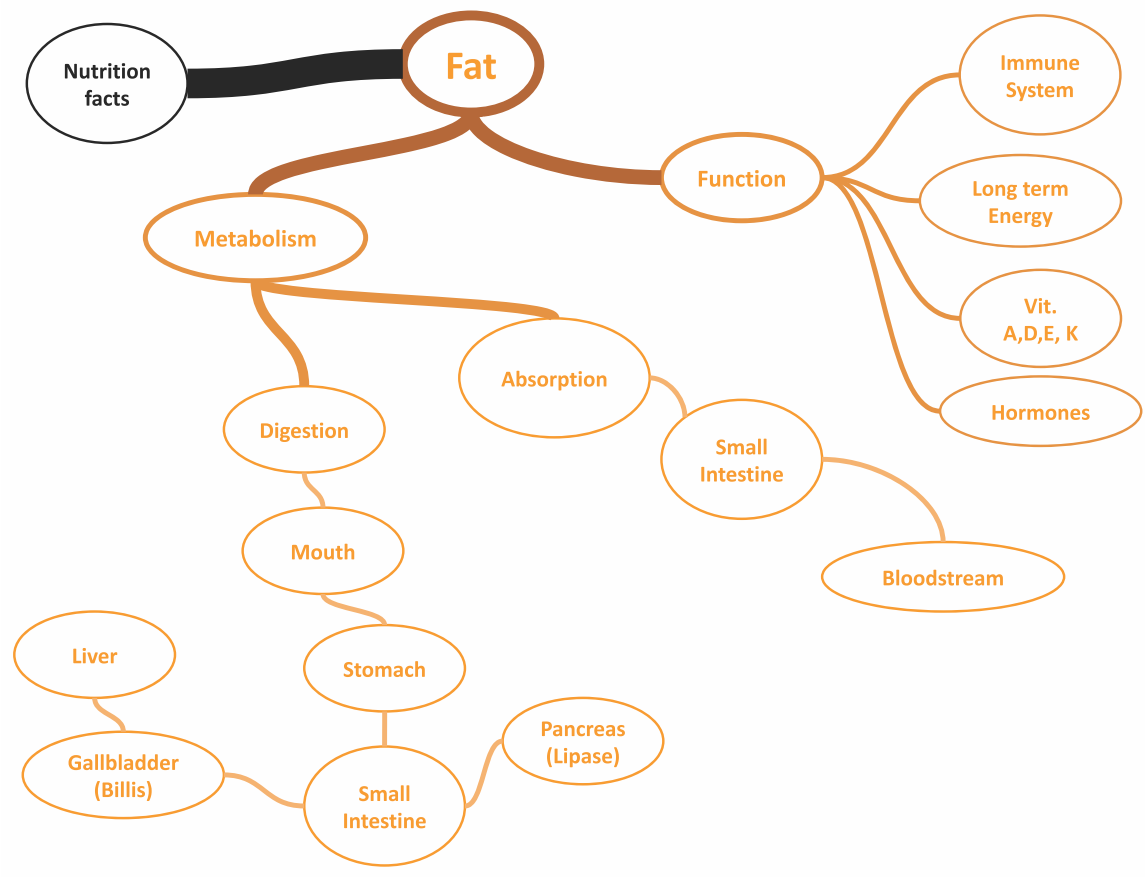
Element	Interrelationship
Potato	Production of potato chips, cultivation, nutriment source
Salt	Production of potato chips, nutriment source
Oil	Production of potato chips, nutriment source
Carbohydrates	Nutriment, source of energy, sugars
Proteins	Nutriment, molecules with important functions in the cell and body
Fat	Nutriment, biggest source of energy in the body
Mouth	Consumption, mix food with saliva, chew, and breakdown of carbohydrate molecules
Stomach	Mixer that is connected by the oesophagus to the mouth on one side and to the small intestine to the other side
Small Intestine	Pancreas, gallbladder, stomach, large intestine, and bloodstream
Large intestine	Bloodstream and the small intestine
Pancreas	Bloodstream and duodenum
Gallbladder	Liver and duodenum
Liver	Gallbladder and bloodstream

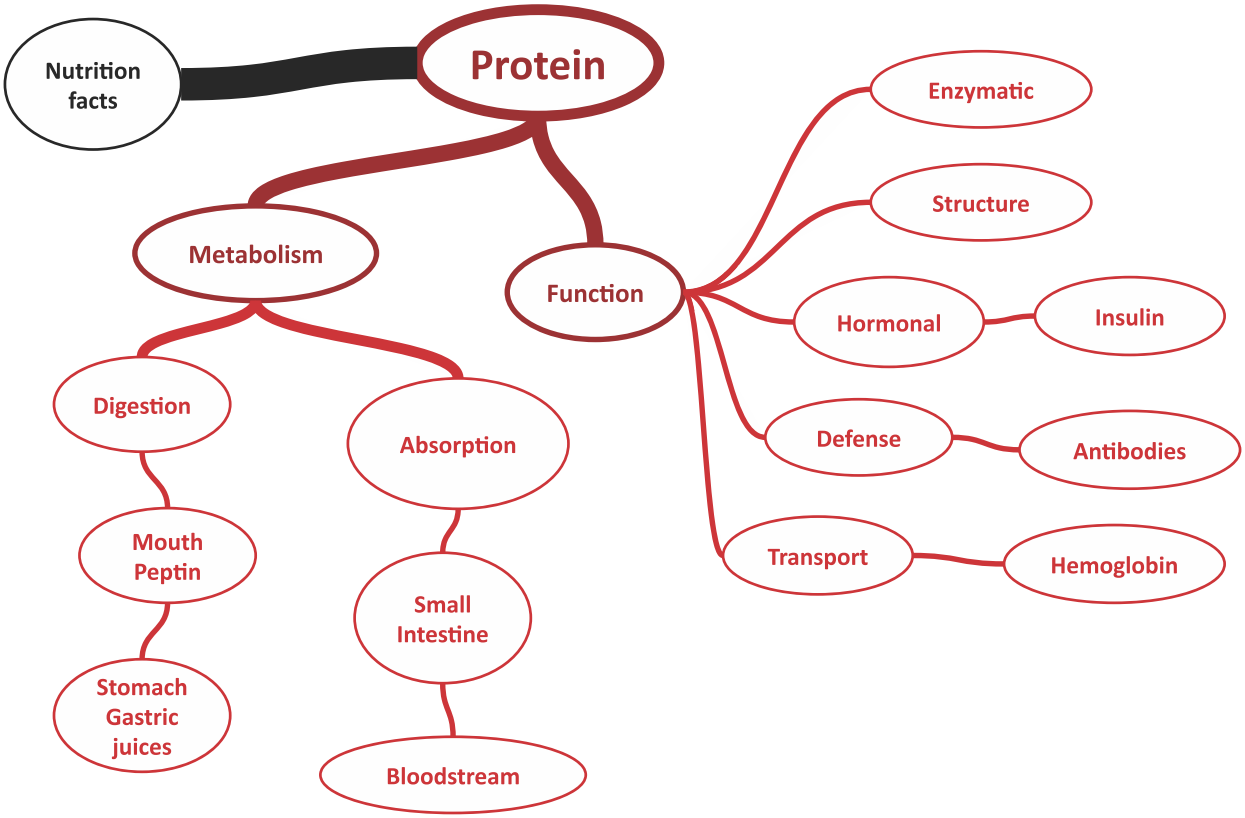
Examples of mind maps for nutrition from potato chips

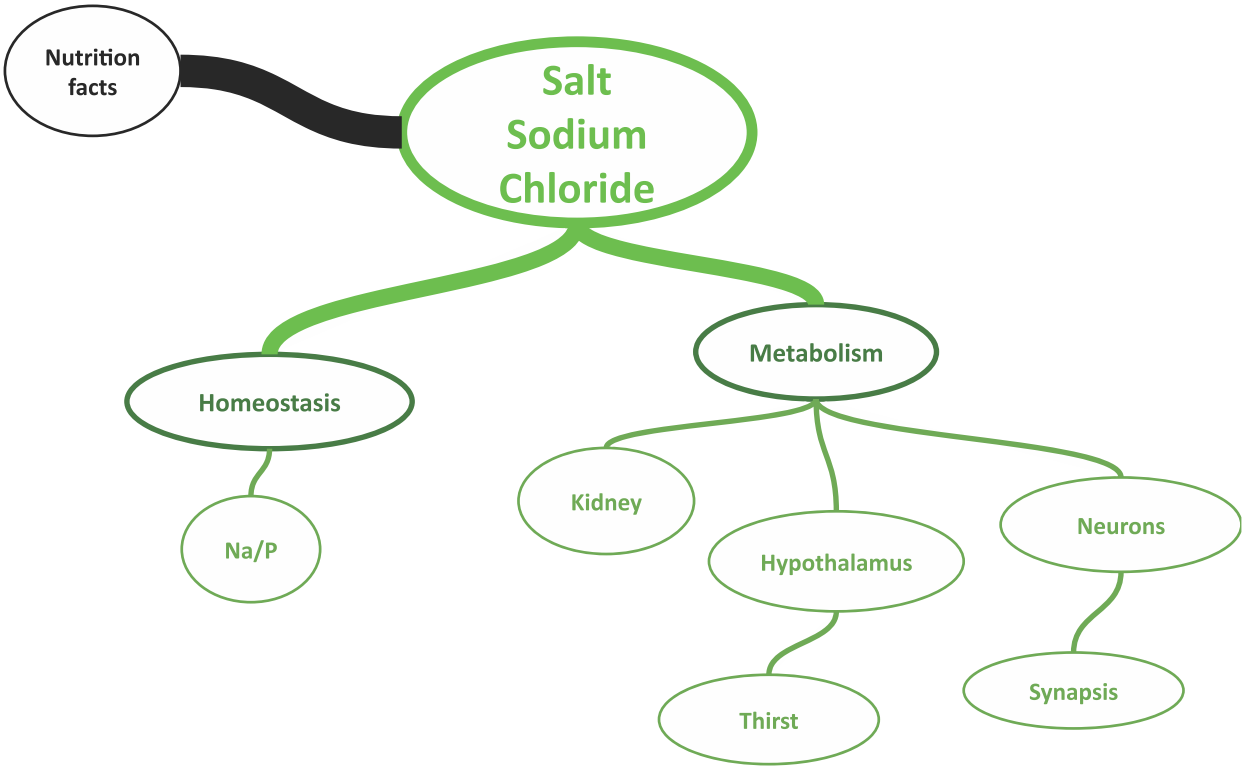
The following Mind maps are an example of possible answers to the questions: How does the human body process potato chips? How does the metabolic process work?

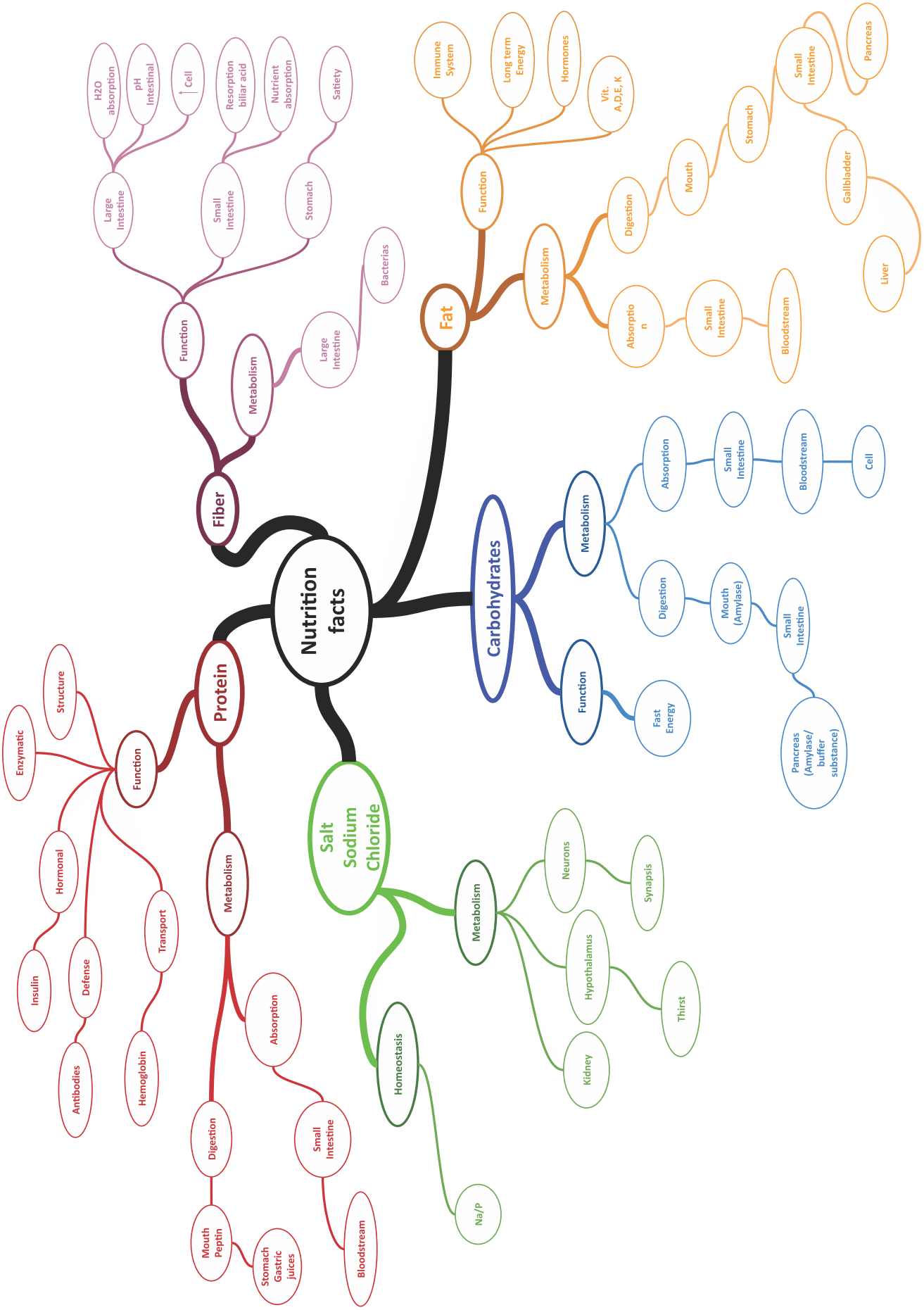



Nutrition facts
Carbohydrates
Function
Metabolism
Fast Energy
Digestion
Absorption
Mouth (Amylase)
Small Intestine
Pancreas (Amylase/ buffer substance)
Small Intestine
Bloodstream
Cell


Nutrition facts
Fat
Function
Immune System
Long term Energy
Vit. A,D,E, K
Hormones
Metabolism
Absorption
Small Intestine
Bloodstream
Digestion
Mouth
Liver
Stomach
Gallbladder (Billis)
Small Intestine
Pancreas (Lipase)


Nutrition facts
Protein
Metabolism
Function
Digestion
Absorption
Mouth Peptin
Stomach Gastric juices
Small Intestine
Bloodstream
Enzymatic
Structure
Hormonal
Insulin
Defense
Antibodies
Transport
Hemoglobin


Nutrition facts
Salt
Sodium
Chloride
Homeostasis
Na/P
Metabolism
Kidney
Hypothalamus
Thirst
Neurons
Synapsis


Nutrition facts
Fiber
Function
Large Intestine
H2O absorption
pH Intestinal
↑ Cell
Small Intestine
Resorption biliar acid
Nutrient absorption
Stomach
Satiety
Metabolism
Large Intestine
Bacterias
Fat
Function
Immune System
Long term Energy
Hormones
Vit. A,D,E, K
Metabolism
Digestion
Mouth
Stomach
Small Intestine
Pancreas
Gallbladder
Liver
Absorption
Small Intestine
Bloodstream
Carbohydrates
Metabolism
Absorption
Small Intestine
Bloodstream
Cell
Digestion
Mouth (Amylase)
Small Intestine
Pancreas (Amylase/ buffer substance)
Function
Fast Energy
Protein
Function
Enzymatic
Structure
Hormonal
Insulin
Defense
Antibodies
Transport
Hemoglobin
Metabolism
Absorption
Small Intestine
Bloodstream
Digestion
Mouth Peptin
Stomach Gastric juices
Salt Sodium Chloride
Metabolism
Neurons
Synapsis
Hypothalamus
Thirst
Kidney
Homeostasis
Na/P

STEP 3

UNDERSTAND THE MODEL OF THE POTATO CHIPS PRODUCTION AND THE POTATO CHIPS NUTRITION AS A SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, **understand the model as a system,** use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Understand whether the model of production of potato chips and the nutrition from potato chips is a system, and if it's a system, is it static or dynamic in nature,
- Become familiar with and use the specific vocabulary of systems approaches (such as element, interrelationship, function, system, dynamism, etc),
- Identify elements such as actors or factors of production of potato chips and the nutrition from potato chips,
- Identify interrelationships among elements in the production of potato chips and the nutrition from potato chips, such as processes, communications, energy or information flows, cultural norms, legislations, or rules,
- Understand that co-functioning elements and interrelationships cause dynamism of systems,
- Understand that a system has integrity (functions as a unit) and has a boundary,
- Understand that a system may be nested as a 'sub-system', within another system, or interrelated with other systems,
- List the outputs of the system/sub-systems.

2. Teaching approaches

Preparation

- Before the activity it is important that learners know the difference between a mind map and a concept map (see the methods), and how to create them.
- Learners should also know the terms used to describe systems and their components: element, interrelationship, behaviour, and dynamics. Introduce the terms by writing them on the blackboard and encouraging the learners to describe what they think these terms mean. Share the definitions and encourage the learners to match the terms to items in the structured description, mind map or concept map they may have prepared.

Activity 1 - How are potato chips made?

Material: TV, Computer, Videos

Analyse a Video

Preparation for the teacher

- Watch the videos.
- Review the further leading questions from step 1 and 2 and add these to the table template below.

Learners' Activity

- Individually read the questions set in the table and write three new questions about things that you wish to know more about.
- Watch the three videos
- Add the information missing in the table with the help of the videos
- Form groups of four and use the method Think, Pair, Share. Share the information that you have. Is any information missing? Did the videos give you all the answers?
- Write further leading questions. What did the movies not talk about? Why do we have different flavours? What are the functions and consequences of the ingredients?

Template to analyze videos about the production of potato chips

Questions	Movie 1 How Kettle Chips are made (Norfolk)	Movie 2 How Pringles are made	Movie 3 Homemade chips in rural India
What are chips made of?			
How are they produced?			
How is the quality control ensured?			
How much time does it take to go from a potato to a bag?			

Activity 2 - Prepare a model of the system

Based on the model (mind map created in Step 2) and the information gathered in the videos, create a concept map about the production potato chips taking into consideration the different elements and their interrelationships, functions, dynamism, and behaviour.

Resources

Norfolk Now (2017, October 17). *A behind the scenes look at how Kettle Chips are made.* [Video]. YouTube. https://www.youtube.com/watch?v=j6dRt0xOqDs

Food Network (2020, February 24). *How Pringles Are Made (from Unwrapped).* [Video]. YouTube https://www.youtube.com/watch?v=6k7rN_GHfkw

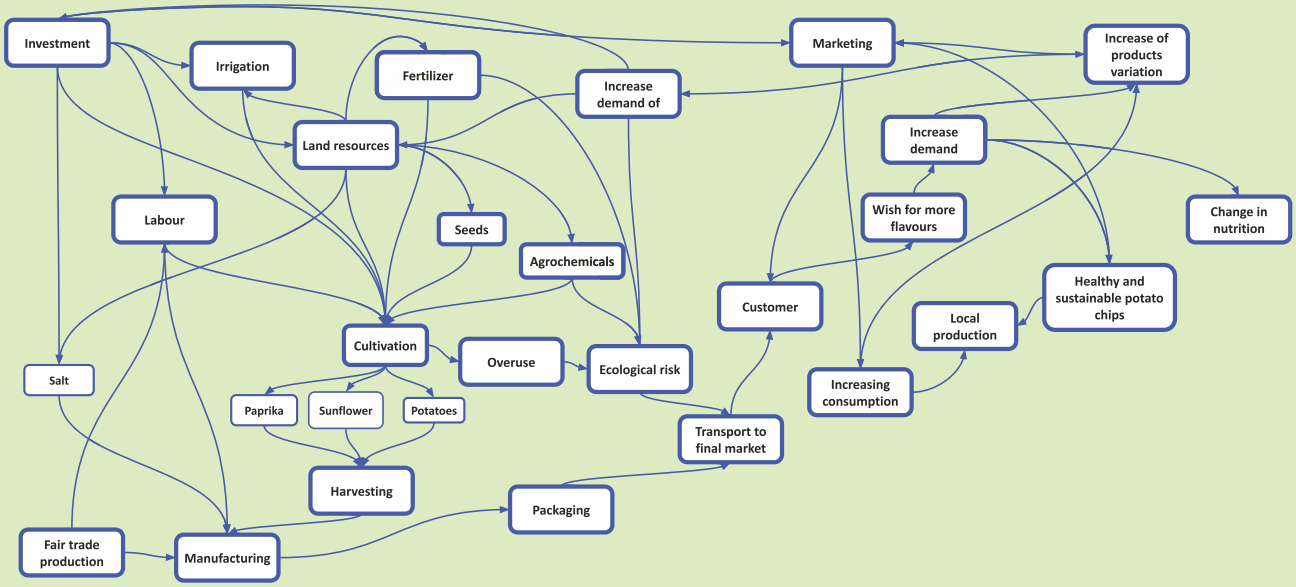
Veg Village Food (2018, December 7). *POTATO CHIPS* . [Video]. YouTube. https://www.youtube.com/watch?v=icPdA1gDfuA

Example of a table to analyse videos about production of potato chips

Questions	Movie 1 How Kettle Chips are made	Movie 2 How Pringles are made	Movie 3 Homemade chips in rural India
What are chips made of?	Potatoes	Potato flakes	Potatoes, salt, oil, masala
How are they produced?	Potatoes are harvested and transported to the factory. The potatoes are washed, peeled, cut in slices, and then fried in oil at 150 degrees. The fried chips are put on a drainage belt, where they are manually inspected. They are then sent to the seasoning platforms and then put in individual bags. The bags are put into boxes and sent out to the customers.	Ingredients are graded at the chips lab. Quality potato flakes are rolled into a flat dough. Chips are cut into the oval or circular shape, baked, and seasoned on one side.	Peel the potatoes, put in water so that they don't become brown, add with salt, cut in slices, add ice to the slices, Wash again with fresh water, put the slices on a blanket for drying, Fry sliced potatoes in hot oil, sprinkle some water, take out from the fry pan, add masala and salt, and serve in small packets.
How is the quality control ensured?	After harvesting, the potatoes go onto a picking table where the defective ones are taken out from the line. After the potatoes are fried, they are manually inspected.	They undergo several quality tests and if the chips do not meet the required quality the whole batch is scrapped.	Quality is ensured during the peeling of the potatoes; low quality potatoes are taken out. Once the potatoes are cut in slices the brown slices are taken out. As the potatoes are not put into machines, the quality check is done while the peeling takes place. The amount of seasoning to be added is judged by experience and not calculated in detail. Quality is good as the food is served immediately after preparation. No long duration storage or preservatives are needed
How much time does it take to go from a potato to a bag?	Takes a rate of 30 minutes from potatoes to the package.		

Why are chips put in separate bags, although they are served and eaten immediately?	Takes 30 minutes from potatoes to the package.		
Would it be possible to serve other flavours? Which ones?	The company has 12 different seasonings.		
Why are the chips not sold, but rather prepared as a present to the community?			
How many households in India prepare chips at home? Is it common to make chips at home? Are there potato chip factories as well?			
How are the new flavours created?			
How are the flavours added to the potato chips?	Spray dry, high heat, high pressure spraying of a liquid that rapidly evaporates any excess moisture and becomes a powder that is collected.		
Do people prefer a specific brand?			

2. Example of a concept map of chips production



Activity 1 - How do we digest potato chips?

Preparatory activity for the facilitator

- Watch the videos.
- Review the further leading questions from step 1 and 2 and add the further information to the table.

Procedure

- Ask the learners to read the questions set in the table and write three new questions about things they may wish to know more about.
- Invite the learners to watch the three videos.
- Learners may add the information missing in the table with the help of the videos.
- Form groups of up to four learners. Use the method Think, Pair, Share, and ask the learners to exchange the that they have. Is any information missing? Did the videos give them all the answers?
- A sk learners to write further leading questions. Examples: What did the movies not mention? How does our body process the chips?

Resources

iDaaLearning (2013, May 9). *Digestion in Human Beings 3D CBSE Class 7 Science.* [Video]. YouTube. https://www.youtube.com/watch?v=zr4onA2k_LY

Whats Up Dude (2018, January 18). *What Is Cellular Respiration - How Do Cells Obtain Energy - Energy Production In The Body.* [Video]. YouTube. https://www.youtube.com/watch?v=hMK1-bgTAtQ

Britannica (u.d.). *How the human body break down and digest food.* Available at https://www.britannica.com/video/187008/chemistry-carbohydrates-humans-fats-proteins

Armando Hasudungan (2015, January 13). *Starch (Carbohydrate) Digestion and Absorption.* [Video] YouTube https://www.youtube.com/watch?v=LWfXeCVp7Wk.

Template to analyse videos about nutrition from potato chips

Questions	Digestion in Human Beings	What is cellular respiration?	Uncover the science behind how the human digestive system breaks down carbohydrates, proteins, and fat	Starch digestion and absorption
How is the digestive system integrated?				
How is digestion carried out?				
How do we absorb the nutrients?				
What is cell respiration?				
How much energy is produced at the end of the cell respiration?				
How can proteins produce energy?				
Where can we find the three food groups?				
How is starch digested?				
What is an enzyme?				
What is the function of the three food groups?				

Activity 2 - Prepare a model of the system

The key factors of a system are: Structure (elements and their interrelationships), Behaviour (changes over time of the status of elements of interest) and Purpose (the independent functions of the elements to achieve a common aim).

Ask learners to prepare a more detailed version of the model of the system, based on the model (mind map) created and the table developed in Step 2 (the extended version, using the Brainstorming method) as well as the information gathered in the videos.

Template to note detailed information about the different elements of the chips nutrition system

Structure of the system		Purpose
Element	Interrelationship	
Saliva		
Stomach		
Protein		
Carbohydrates		

Based on the above, what is the behaviour and purpose of the nutrition line system of potato chips?

Example of a table to analyse videos about nutrition from potato chips

Questions	Digestion in Human Beings	What is cellular respiration?	Uncover the science behind how the human digestive system breaks down carbohydrates, proteins, and fat	Starch digestion and absorption
How is the digestive system integrated?	It is integrated from the mouth down to the anus.			
How is digestion carried out?	It starts in the mouth, buccal cavity, and continues through the oesophagus, stomach, large intestines, small intestines, the rectum, and anus		It is like a disassembly line. The body breaks down the food and absorbs the nutrients, and discards the waste.	
How do we absorb the nutrients?	Nutrients are absorbed into the blood in the small intestine. Unabsorbed food passes through the large intestines, to the rectum, and then the		Once the molecules are broken down the microvilli of the small intestine absorb the nutrients into the bloodstream.	
What is cell respiration?		Food broken down into glucoses inside the cell is used to produce energy. It has four main stages: Glycolysis, Intermediate state, Citric acid cycle and Electron transport		
How much energy is produced at the end of the cell respiration?		The energy produced in the different steps of the cell respiration: Glycolysis 2ATP Citric acid cycle 2ATP Electron transport 34 ATP However, the average set is between 28 to 30 because some parts of the process require ATP		

How can proteins produce energy?		Normally the body does not use proteins (amino acids) to produce energy, however if it is necessary, the body uses the amino acids. First, the amino NH group has to be removed. Once this is done, the different amino acids can enter cell respiration in different stages.		
Where can we find the three food groups?			Carbohydrates: Vegetables, fruits, dairy products, bread and candies. Proteins: Animal sources like dairy, fish, chicken, and plant sources such as grains, nuts and vegetables.	
How is starch digested?		Starts in the mouth with the Alpha-amylase in the saliva.	Starch digestion starts with the saliva produced in the salivary glands. The saliva partially digests the starch, because once the food goes into the oesophagus the amylase enzyme is inactivated. The digestion process continues once the food goes out of the stomach into the small intestine, where the pancreas also adds some molecules. In the small intestine, starch is converted into glucoses. Some of it goes through the cells into the blood, and from there the glucose goes into either the lever or is transported as energy to the muscle cells. Resistant starch continues its way to the colon (large intestine)	

What is an enzyme			Molecules that speed up reactions. They are proteins that catalyse reactions.	
What is the function of the three food groups?			Carbohydrates: Produce energy, quick boost. Fat: Fatty acids are used to construct cell membranes. Fat is a great source of energy. Proteins: used to make hormones, bones, muscle, skin and blood.	
How are the three food groups broken down?			Hydrolysis, a break of a compound when it reacts with water.	
Where do we find Starch?			Potatoes, corn and rice	

The purpose is to fulfil the needs of the body, produce energy, maintain the system, and keep you in shape (balancing and reinforcing).

The pancreas does the balancing work in the digestive system of the body.

The behaviour of the system depends on the type of nutrition and daily activity of the person (Metabolism)

Example of a filled in table on elements, interrelationsships and functions of the elements on the basis of the new information from the video analysis

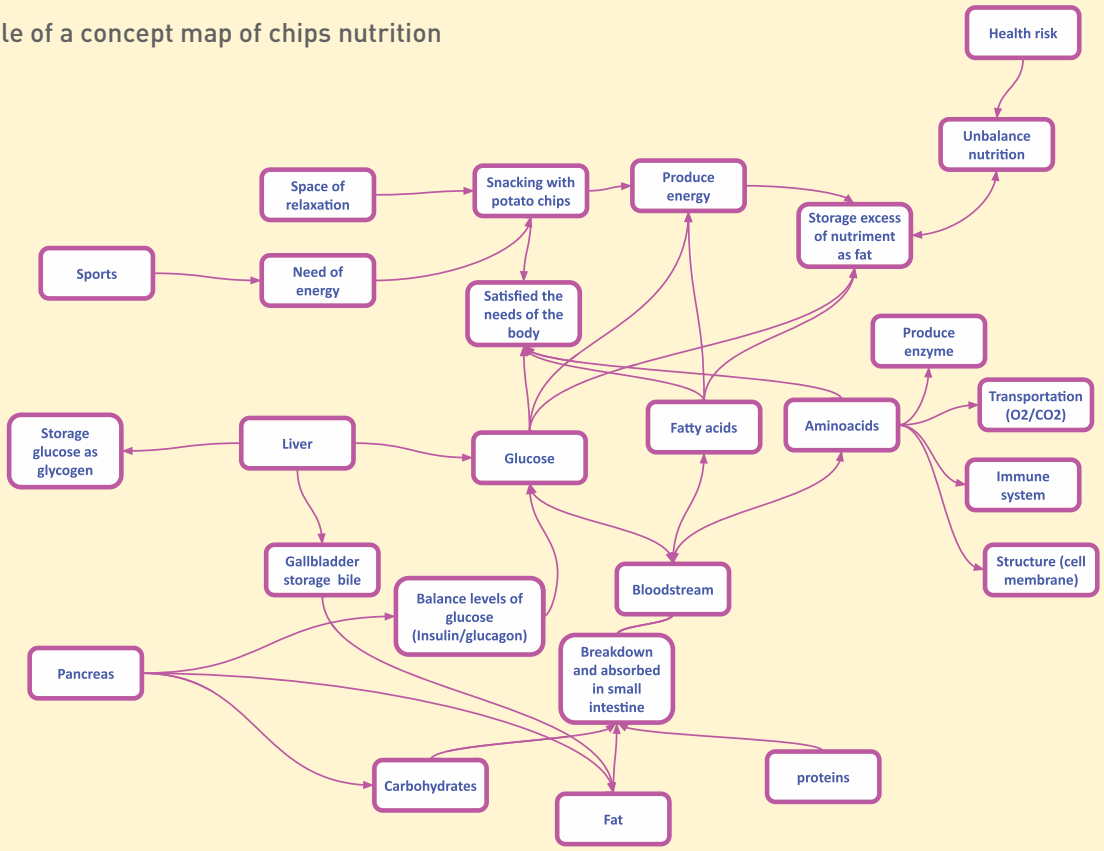
Structure of the system		Purpose of the system
Element	**Interrelationship**	**Function of the elements**
Potato	Production of potato chips, cultivation, nutriment source.	Contains starch
Salt	Production of potato chips, nutriment source.	Na/P exchange in cells. Regulation of fluids in the body (homeostasis)
Oil	Production of potato chips, nutriment source.	Fat source
Carbohydrates	Nutriment, source of energy, sugars.	Generate boost energy in the body
Proteins	Nutriment, molecules with important functions in the cell and body.	Their functions are transport, defence, hormone production, enzymatic reactions, and give structure.
Fat	Nutriment, biggest source of energy in the body.	Biggest source of energy
Mouth	Consumption, mix food with saliva, smash?, breakdown of carbohydrate molecules.	Breakdown of the food and the molecules, mix with the saliva which contains the amylase enzyme.

Structure of the system		Purpose of the system
Element	**Interrelationship**	**Function of the elements**
Stomach	Mixer that is connected by the oesophagus to the mouth on one side and to the small intestine to the other side.	Mix the food with gastric juice, which contains pepsin and lipase. The enzymes to breakdown carbohydrates are inactivated due to the acid in the stomach.
Small Intestine	Pancreas, gallbladder, stomach, large intestine and bloodstream.	The gallbladder and the pancreas send their secretion into this portion. Here the breakdown of the molecules is completed and most of them are absorbed via the microvilli into the bloodstream
Large intestine	Bloodstream and the small intestine.	Here the remaining nutrients are absorbed as well as water. Contains bacteria that break down fibre.
Pancreas	Bloodstream and duodenum	Produces Insulin that is sent into the bloodstream to help the cells use glucose. Produce pancreatic juice that is sent into the small intestine, which acts as a buffer solution, changes the pH and allows the amylase enzyme to start working again. The pancreatic juice also contains lipase.
Gallbladder	Liver and duodenum	Storage of bile, which contains lipase enzymes.
Liver	Gallbladder and bloodstream.	Produce bile and send it to the Gallbladder. The liver performs several roles in the nutrients metabolism once they have been absorbed from the digestive tract.

Activity: Create a concept map of the potato chips digestion process

Ask the learners to create a concept map, taking into consideration the elements, interrelationships, system or sub-system and the function of the digestive system.

Example of a concept map of chips nutrition



Learning methods

- Analysis Matrix
- Mapping Technique: Mind Map
- Mapping Technique: Concept Map
- Video Content Analysis
- Think, Pair, Share
- Brainstorming

3. Further leading questions

- What else would I like to find out now?
- Are chips produced in my area?
- How many different brands and flavours can I buy in my neighbourhood shop?
- Why do I like a particular brand the most?
- Are there enough potatoes to produce more and more potatoes?
- Do people in other countries eat as many chips as we do?
- Is the distance of each product to the production place?
- Why is the price so different?

- How many people are needed to produce chips?
- Why do companies always produce new flavours?
- Do we have enough potatoes in the world?
- What else is made of potatoes?

- What is the nutritional value of the potato chips?
- How healthy are potato chips?
- Since when do we eat potato chips?
- How were potato chips integrated in our daily life?

STEP 4

USE THE MODELS OF POTATO CHIPS PRODUCTION AND POTATO CHIPS NUTRITION TO EXPLAIN THE DYNAMIC BEHAVIOUR OF THE SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to explain the current and past behaviour of the system of the production of potato chipsand the nutrition from potato chips.

2. Teaching approaches

Activity: Chips production TV news 1980 and 2020

- Form two groups of learners exploring the potato chips production system. One team will work with the information from 1980 and the other with information of 2020.
- Each group should conduct a brief study about how potato chips were produced in the allocated year. The group may use the information from Step 2 and 3, internet search or other sources. Kindly rephrase, Suggestion: Learners may also apply the Interview method and talk to their parents or grandparents and ask about their childhood experiences and memories associated with potato chips. Possible guiding questions: available flavours, availability in stores, eaten at which occasions, size of packages, number of brands, reason for eating, etc.
- Remember that we are talking about two moments of the system, one in 1980 and the other in 2020.
- Learners try to identify balancing or reinforcing structures in the system. This could be done with a graphic representation (Behaviour over Time Graphs).
- The groups present an Explainer video or podcast as a program called "TV News 1980" or "TV News 2020". They may search for advertisements on the potato chip brands of those years and include it in their TV show.
- The videos and/or podcast are presented to the group.
- In a plenary session, the learners reflect on how the behaviour of the system of the potato chips production has changed from 1980 to 2020. They present the change over time, showing how balancing and reinforcing structures have influenced the system.
- Formulate further leading questions.

Resources

FAO (u.d.). *Potato World.* Available at http://www.fao.org/3/i0500e/i0500e03.pdf

Data Salon (2019, December 31). *Largest Potato Producing Countries in the World* 1960-2019. [Video]. YouTube. https://youtu.be/bPIMVgYQh3s

Mordor Intelligence (u.d.). *Potato Chips Market Growth, trends and forecast (2020-2025)*

https://www.mordorintelligence.com/industryreports/potato-chips-market

Potato Grower (u.d.). *It's a Small World.* Available at https://www.potatogrower.com/2019/05/its-a-small-world#

Example of an interview about the production and consumption of potato chips in the 1980s

Interview with Nicola P. (Germany)

Question: What was the experience of the production and consumption of potato chips when you were a child in the 1980s.

I remember that we rarely had occasions when we ate potato chips. Of course, we bought them for birthday parties. I remember that my aunt bought a huge carton of chips on New Year's eve. The carton of chips was as big as a carton of washing powder. Later, she used to upcycle these packages as wastepaper baskets by decorating them with leftover bits of wallpaper.

Also, large cartons of chips accompanied big occasions when friend and family got together such as the world soccer finals. My uncle and aunt bought a bag of chips as a snack when they received guests in the evening for playing cards together. I personally had chips sometimes on Saturday evenings as well, e.g., during certain films which I was watching on TV with my parents, such as "Wetten, dass ...?" or "Dalli" or "Der große Preis" (famous shows on German television since the 1970s).

The chips came from the company Bahlsen, now Lorenz (Bahlsen). This was the only chips brand we could buy in shops. There was generally only one package size. The extra big boxes were sold at special times, such as New Year's Eve or soccer events.

It was only in the early nineties when I was travelling to the United States (US), that I found out that chips can accompany a main dish. In the US it was served with a club sandwich or chips were eaten as Nachos with certain dips. When I came back to Germany, I realised that suddenly many of the chip I ate in the US, such as Pringles and Lays, were also being sold in Germany. Pringles chips were sold by Bahlsen before that. Therefore, the idea had reached Germany before the import of US branches started.

I do not remember any TV advertisements of potato chips those days. As far as I know, not many flavours were available. The most common was Hungarian style Pepperoni flavoured chips. I do not remember why they are named so, but I assume that they have the flavour of a dish called Hungarian Gulash, which is flavoured with pepperoni.

The first time I ate chips of different flavours was in the US or in England. In the US they had sour cream and onion as well as cheese flavours and in England there was salt and of course salt and vinegar.I think most chips were made of sunflower oil, as it was the most common oil available at that time. It was only later that palm oil was used and the ingredients were imported from other countries as these reduced costs in mass production.

Activity - Chips Digestion TV News 1980 and 2020

- Two teams of learners explor the potato chips nutrition system. One team will work using information from 1980 and the other will work with information of 2020.
- Each group should conducts a small study about the normal diet and the consumption of the potato chips in the specified years. They may use the information from Steps 2 and 3 and search on the internet or use other sources. Remember that we are talking about two moments of the system in 1980 and 2020, it is important that the learners identify one or the two system structures balancing or reinforcing.
- The groups may present an Explainer video or podcast as a programme called "TV news 1980" or "TV news 2020". They may search for advertisements on the potato chip brands of those years and include it in the programme.
- The videos and/or podcast is presented to the group.
- In a plenary session ask the learners to reflect on how the behaviour of the system of the potato chips consumption has changed from 1980 to 2020. One important element is to present the change over time. This may be done with a suitable graphic representation that the learners like.
- Invite the learners to formulate further leading questions.

Resources

TED-Ed (2015,February 19). *What does the pancreas do? - Emma Bryce.* [Video]. YouTube. https://youtu.be/8dgoeYPoE-0

The Guardian. (2013, May 6). *Hungry Planet: What the World Eats - in pictures.* Available at http://www.theguardian.com/lifeandstyle/gallery/2013/may/06/hungry-planet-what-world-eats

National Geographic Magazine (u.d.). What the *World Eats.* Available at https://www.nationalgeographic.com/what-the-world-eats/

Gilbert, Sarah (2019). *What children around the world eat in pictures.* The Guardian. Available at https://www.theguardian.com/lifeandstyle/gallery/2019/jul/02/what-children-around-the-world-eat-in-pictures

Learning methods

- Interview
- Behaviour over Time Graphs
- Mapping Technique: Mind Map
- Explainer Video
- Podcast

3. Further leading questions

- What situation will come up if we continue chips production and assumption as in the last years?
- How does this affect the general health of people?
- What is the environmental impact of this system?
- How is the social status of people influenced by the nature of consumption?

STEP 5

ANTICIPATE THE FUTURE BEHAVIOUR OF THE SYSTEMS OF POTATO CHIPS PRODUCTION AND POTATO CHIPS NUTRITION

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- recognize that by using a systems model, it may be possible to anticipate potential future scenarios of potato chips production and the impact of eating chips on the health of people, and
- use systems models to make projections about the potato chips production/potato chips consumption systems.

2. Teaching approaches

Activity - Scenario Analysis for potato chips production

Ask learners to use the internet research method. explore how many tons of potato are produced per hectare. The learners' task is to identify the percentage of increase or decrease of the potato production in the last 30 years. To do so, they may visit the Potato PRO website.

This website lists potato producing countries. Choose one of the countries and click on the name.

Note to the facilitator: In case the Potato Pro webpage does not work, search for a reference that provides you the annual production of potatoes in the last 30 years.

- Learners may calculate the increase or decrease in the production of potato from 1997 to 2007 to 2017.
- Next, they calculate the weekly production of potatoes in a year. Take the production per year and divide by 52 weeks.
- Watch again the video "How Kettle Chips are made"

  How has the production of potato chips changed over the years? How many potatoes were used in 1988 and 2018? Analyse if the number sounds correct to you.

  Note to the facilitator: please note that the content of this video may have an error related to the quantity of production of chips, and this is integrated into the activity. See the example later in this step for details.
- Based on the quantity of potato produced (tons per hectare), what is the land area in hectares used to produce this weekly quantity of potatoes? Make the calculations for 1997, 2007 and 2017.
- Let's consider a possible scenario: Calculate the quantity of potatoes we will produce if we increase the production by 50% from 2017 to 2027. What is the area of agricultural land needed (in hectares) if the production of potato chips is increased by 50%?

Activity - Time to reflect

After they finish the calculations, let learners answer the following questions:

- What will be the quantum of potato production by 2047, if the rate of increase is the same as in the last 30 years?
- Based on the previous calculation, imagine a future where the production will be 25% less than the average production of the last 30 years.
- Can you think of a production scenario that provides better conditions for the workers (salary, health care, workers' rights, etc)?
- Analyse what proportion of the world production of potatoes is used for potato chip production.
- Imagine, what will happen if we feed the world with potato chips? When working on your scenario analysis, Consider the increase in the quantity of water used for irrigation and production, salt and oil, and anticipate consequences of this scenario not only for the consumers, but also of people who may be affected by the increase all the resources needed.
- Impacts on people may differ, according to the part of the potato chip production process they are related to: work in the chip factories, live next to the potato fields, farmers who grow potatoes in various parts of the world, and other components of the potato chip production system. You may ask the learners to take these additional consequences into account, when doing their scenario analysis or define further leading questions on how the scenarios will impact other elements (to be defined) of the system.

After the activity, encourage the learners to develop further leading questions.

Resources

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WikiFarmer Editorial Team (2021). *Potato Harvest Yield & Storage.* Available at https://wikifarmer.com/potato-harvest-yield-storage/

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FAO (2008). *Potato world: Production and Consumption—International Year of the Potato 2008.* Available at https://www.fao.org/potato-2008/en/world/index.html

Norfolk Now (2017, October 17). *A behind the scenes look at how Kettle Chips are made.* [Video]. YouTube https://www.youtube.com/watch?v=j6dRt0xOqDs

Example of a Scenario Analysis for potato chips production

- **Preparatory activity information**

  In the first year of potato farming, the yield may be about 25 tons per hectare.
  In subsequent years, a farm may achieve yields from 40 to 70 tons per hectare.

- **Let's make some calculations**
  - The learners' task is to identify the percentage of increase or decrease in potato production in the last 30 years. To do so, go to the Potato pro web page. In there you will find the list of the 25 producing potato countries. Choose one of the countries and click on the name.
  - Calculate the increase or decrease in the production of potato from 1997 to 2007 to 2017

* In case the page does not work, search for a reference that provides you the annual production of potatoes in the last 30 years.

CHINA			RUSSIA		
1997	2007	2017	1997	2007	2017
57,260,000 tons/year	64,837,400 tons/year	99,205,600 tons/year	37,039,700 tons/year	36,784,200 tons/year	29,590,00 tons/year

CHINA		
From 1997 to 2007 64,837,400 - 57,260,000 = 7,577,400 7,577,400 / 57,260,000 = 0.1323 0.1323 x 100 = 13.23% (Tons/year 2007)-(Tons/year 1997) = Result A Result A / (Tons/year in 1997) x 100 = % of increase	From 2007 to 2017 99,205,600 - 64,837,400 =34,368,200 34,368,200 / 64,837,400 = 0.5339 0.5339 x 100 = 53.39%	From 1997 to 2017 99,205,600 - 57,260,000 =41,945,600 41,945,600 / 57,260,000 = 0.7325 0.7325 x 100 = 73.25%

RUSSIA		
From 1997 to 2007 37,039,700 - 36,784,200=255,500 255,500 / 37,039,700=0.0068 0.0068 x 100 = 0.68% (Tons/year 1997)-(Tons/year 2007) = Result A Result A / (Tons/year 1997) x 100 = % of decrease	From 2007 to 2017 36,784,200 - 29,590,000=7,194,200 7,194,200 / 36,784,200 = 0.1955 0.1955 x 100 = 19.55%	From 1997 to 2017 37,039,700- 29,590,000=7,449,700 7,449,700 / 37,039,700 = 0.2011 0.201100 = 20.11%

- **Now, let's calculate what will be the average weekly production of potatoes in a year.**
  Take the production per year and divide by 52 weeks.

CHINA		
1997	2007	2017
57,260,000 / 52 = 1,101,153 tons/week	64,837,400/ 52 =1,246,873 tons/week	99,205,600/ 52 =1,907,800 tons/week

RUSSIA		
1997	2007	2017
37,039,700/ 52 = 712,301 tons/week	36,784,200/ 52 = 707,388 tons/week	29,590,000/ 52 =569,038 tons/week

- Watch again the potato video ("How Kettle Chips are made" in Step 3,
- How much has the production of potato chips changed over the years? How many potatoes were used in 1988 and 2018?
- Note that there is a missing term in the video. The captions at 1 minute, 20 seconds explain that in 1988 they used 3 tons of potatoes per year, and at present they use 50,000 tons per year. The next caption is '6 million every week', but it is not clear what the 6 million refers to. Is it the number of potatoes used every week? Or the number of packets of chips produced every week?
- Based on the number of tons produced per hectare, how many hectares are used to produce this weekly quantity of potatoes. Make the calculations for 1997, 2007 and 2017.

CHINA		
1997	2007	2017
1,101,153tons/40 tons= 27,528 ha	1,246,873/40 tons= 31,171ha	1,907,800/40 tons= 47,695 ha

RUSSIA		
1997	2007	2017
712,301/40 tons= 17,807 ha	707,388/40 tons= 17,684 ha	569,038/40 tons= 14,226 ha

- Let's see a possible scenario. Calculate the quantity of potatoes we will produce if we increase the production by 50% from 2017 to 2027. What area of farmland will be needed?

CHINA		
2017	2027 (+50%)	2027
99,205,600 tons	148,808,400 tons/year 2,861,700 tons/week	71,542ha (40 tons per ha)

RUSSIA		
2017	2027(+50%)	2027
29,590,000 tons	44,385,000 tons/year 853,557 tons/week	21,338ha (40 tons per ha)

Activity: Scenario Analysis for consumption of potato chips

- Ask learners to conduct internet research to answer the following questions:
  - How many calories does a teenager with average exercise/ movement need in a day?
  - What are the meals in a day? How best can we distribute the intake of calories during the day for a good diet?

- Ask learners to take up the following tasks for the scenario discussions
  - Check the nutrition information on the packets used in Step 1 and Step 2 to note the calories in one packet.
  - What proportion of the calories needed in a day are consumed if you eat one packet of potato chips?
  - Does it matter what kind of calories we consume? Justify your answer.
  - Investigate what happens with your appetite when you eat fat and salt in combination.
  - Considering that we do not only eat potato chips the whole day, what else do people eat over a day?

    You may refer to sources such as 'What the world eats' project

Scenarios

  - Imagine the worst-case scenario that the bad calories people consume will increase in the future. What are the probable consequences for their health?
  - Imagine the best-case scenario that the bad calories people consume will decrease in the future. What are the consequences for their well-being?
- Collect further leading questions listed by the learners.

Resources

National Geographic (u.d.). *What the world eats.* Available at https://www.nationalgeographic.com/what-the-world-eats/

TEDMED (2010, May 7). *Peter Menzel at TEDMED 2009.* [Video]. YouTube. https://www.youtube.com/watch?v=ZsYOhRdlpuw&feature=emb_logo

AsapSCIENCE (2018, November 29). *What if you only ate chips?* [Video]. YouTube. https://www.youtube.com/watch?v=-Omnk3C-1YA

3. Further leading questions

Ask the learners to list further leading questions.

Example of a Scenario Analysis for potato chips consumption

Preparatory activity information

Here is a possible solution. The learners should be aware that the average intake of calories per day depends on gender, activity, age, context, and climate.

- Calories needed by a teenager with average exercise/movement per day:

  Boys 2500 – 3000
  Girls 2200

- How best can we distribute the calories during the day for a good diet?

  30 % Breakfast
  15% Morning snack
  30% Lunch
  10 % Evening snack
  15% Dinner

Learners' tasks for the scenario discussion

- Check the package used in Step 1 and Step 2 and review how many calories the package has.

  For example, 100g = 541 kcal
  Package of 105g = 568 kcal

- What proportion of calories needed in a day can you get from a single packet of potato chips?

Boys (3000 kcal)	Girls (2200 kcal)
30 % Breakfast = 900 kcal 15% Morning snack = 450 kcal 30% Lunch = 900 kcal 10 % Evening snack =300 kcal 15% Dinner =450 kcal	30 % Breakfast = 660 kcal 15% Morning snack = 330 kcal 30% Lunch = 660 kcal 10 % Evening snack = 220 kcal 15% Dinner = 330 kcal
3000 = 100% 568 = X568 = X X = 18.93% of the daily kcal recommended	2200 = 100% X = 25.81% of the daily kcal recommended

- Does it matter what kind of calories we consume? Justify your answer.

  Not all calories we eat are the same. The difference between calories that are good and bad for the body is important. Calories from proteins are good for the body when taken in moderation. Calories found in rapidly absorbed sugars, which for each gram provide four calories that if not consumed quickly will accumulate, that is, a person will gain weight.

- Investigate what happens with your appetite when you eat fat and salt in combination?

  Fat and salt are a common combination in many cooked as well as processed food. Over consumption of fat and salt can lead to illnesses of the heart and blood circulation in the body.

- Considering that we don't eat only potato chips during the day, what else do people eat during the day? You may like to introduce to your learners the webpage "Hungry Planet: What the world eats" project.

Scenarios

- Imagine the worst-case scenario that the number of calories people consume will increase in the future. What are the probable consequences for their health?

- Imagine the best-case scenario that the number of bad calories people consume will decrease in the future. What are the likely consequences for their well-being?

When conducting the scenario analysis, learners should consider aspects such as how the change of diet affects other parts of society, the health system, consequences for producers involved in the potato chip production, etc.

When we think of a future scenario, it is important not only to analyse the production increase, but also to anticipate further factors, which will influence the system, such as the need to convert farmland producing other crops to produce the potatoes and oil seeds for the frying, water for irrigation and production, and salt.

Encourage learners to take these additional consequences into account, when doing their scenario analysis and to list further questions on how the scenarios will impact other elements (to be defined) of the system.

Extension Activity: Nutrition Labels

Note for the facilitator: This part of the activity is directly related to the question "Does it matter what kind of calories we consume?" in the Activity "Scenario Analysis for consumption of potato chips".

Knowing the nutritional composition and understanding the percentage of sugar, sodium, fibre and saturated fat provides the possibility to make a conscious decision about what we eat. To improve the understanding of the importance of the type of calories we consume you can address the following questions to the learners:

- Does food packaging have labels in your city or country? Why should food have labels?
  Once they present their first impressions, ask learners to conduct internet research on types of labels, for example on nutrition, fortification with Iodine or other micronutrients (related to nutrition).

- Are the labels clear and easy to understand? Why is this important?

- Should there be labelling about the production of food as well (for example about the presence of agricultural produce from genetically modified organisms (GMOs) in the food, or organic produce)?

Example of labels on food packages around the world

Nutri-score (Europe)

Examples of Food Labelling in Mexico

From left to right: Excess calories, excess sodium, excess trans-fat, excess sugar, excess saturated fat.

Fairtrade

Genetically modified organisms

National Programme for Organic Production (India)

Resources

Colruyt Group (u.d.). *What is the Nutri-Score?* https://nutriscore.colruytgroup.com/colruytgroup/en/about-nutri-score/

Ducrot, P. (2019, December 5). *Nutri-Score: The story so far.* EuroHealthNet. https://eurohealthnet-magazine.eu/nutri-score-the-story-so-far/

Mexico News Daily (2020, October 1). *New warning labels now required on packaged foods.* https://mexiconewsdaily.com/news/new-warning-labels-now-required-on-packaged-foods/

Fairtrade International (n.d.). *What is Fairtrade?* https://www.fairtrade.net/about/what-is-fairtrade

Berry, D (2021, January 21). Food Business News. *Preparing for GMO labeling in 2022.* https://www.foodbusinessnews.net/articles/17559-preparing-for-gmo-labeling-in-2022

Agricultural and Processed Food Products Export Development Authority (u.d.). *National Programme for Organic Production.* http://apeda.gov.in/apedawebsite/organic/Organic_Products.htm

Learning methods

- Internet Research
- Scenario Analysis

3. Further leading questions

- What is the use of looking into the future (with a systems model)?
- Having anticipated future situations with the help of systems analysis, can you also understand whether these will be positive or negative situations? Is that the future you want?
- Can human beings change the behaviour of systems?

STEP 6

EVALUATE THE BEHAVIOUR OF THE POTATO CHIPS SYSTEM IN THE FRAME OF SUSTAINABLE DEVELOPMENT

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and **evaluate its impacts on sustainable development,** identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- become aware of the concept of sustainable development,
- become aware of various frameworks and their respective criteria (presented in the Worksheet"Measuring Development") to assess development and sustainable development, and their strengths and limitations, and
- evaluate the current and future behaviour of selected parameters for their impact on sustainable development.

2. Teaching approaches

This step is quite ambitious because we will deal with two levels of complexity. On the one hand, the two perspectives of work (potato chips production and potato chips nutrition) will be interlinked. On the other hand, the learners must become familiar with the concepts of measuring standards of living, development, and sustainability. The learners are expected to use a suitable framework to evaluate the contribution to sustainable development (or otherwise) from the contemporary chip systems. Conducting some preparatory activities about the topic "sustainable development" would be helpful to adapt to the chips system context.

For the next group work sessions you can form new groups mixing those who earlier worked on chips production with learners who worked on nutrition.

From this part onward we will continue to work in one system and therefore there will no longer be a distinction of colours for the activities.

Activity 1- What is sustainable and what is not sustainable?

Materials

Copies of:

- Information sheet What is sustainable development?
- Worksheet Potato Chips: Sustainable or unsustainable?

Procedure

- Let learners form pairs and read the text "What is sustainable development?"
- Next, share with learners the worksheet "Potato Chips: Sustainable or unsustainable?" and let them work individually to decide which activities are sustainable and which are unsustainable, and give reasons for their decisions.
- Each will also try to list three more activities that can be deemed sustainable or unsustainable.
- They compare results with their partner and discuss their reasoning. Encourage them to think about if modifications and to list if any questions arise as they try to assess whether any action or consequence adds to sustainability.

Activity 2 - Matching pictures with SDGs

Materials

Photos and laminated cards of each SDG

Preparation

- Print out the icons for all the SDGs (arranging 2 on each page, so they are large enough for the activity) and photos of a range of human activities. You may like to check the pool of selected photos available at this link. https://www.ceeindia.org/systemsthinking/resources/

You can choose and print out one or more sets, depending on the number of learners.

- You may want to add or choose other photos from your own photo pool or resources on the internet. Pexels and Pixabay are two possible sources of royalty-free photos.

Procedure

- Spread the selected photos on the floor.
- Invite a pair of learners (one each from those who were exploring chips production and nutrition earlier). Their task is to:

  Look through the photographs and find pairs of photographs, which are linked to one or more of the SDGs.

  They may locate two or three pairs, with one photograph representing a valuable contribution and the other photograph representing a counterproductive activity to the aim of the SDG.
- Invite each pair to present the results of their photo matching and their reasoning. Let the whole class participate in the discussions and reflections.

After this matching exercise, you may ask learners to reflect, which SDGs are related to the topic of potato chips production and consumption on the basis of the knowledge they have.

Photo by Thomas Hoffmann

Guiding questions

- What is the average income of a factory worker, farm worker, driver, or merchant?
- Are potatoes grown organically, or by using chemical fertilizers and pesticides?
- What is the gender ratio of workers engaged in potato chips production?
- Who eats more potato chips, men or women? Why is this relevant?
- How does the way we eat contribute to climate change

Activity 3 - Analyse Potato Chips production against the SDGs

Print out the Worksheet "SDG Analysis Matrix"

- Ask the learners to take a look at the potato chips system and analyse which elements from their systems models (production line and nutrition line) contribute to a specific SDG or are counterproductive to the SDG targets. They should write their conclusions in columns one and two. In the third column they should write the elements in the system that contribute to one SDG and pose a problem for another SDG.

- Learners should use the various elements in their models (production line and nutrition line), and see how these may match with the different SDGs.

Resources

Information sheets

What is sustainable development?

Photo banks

Pexels https://www.pexels.com/
Pixabay https://pixabay.com/

Worksheets

- Potato Chips: Sustainable or
- unsustainable?
- SDG Analysis Matrix

Learning method

Analysis Matrix

3. Further leading questions

- How can I as an individual influence the improvement of SDG?
- How can my actions have an impact in my community and help in achieving the SDGs for the future we want?
- How can we enjoy a pack of sustainable potato chips? Will it be healthier?
- How can the production of potato chips be improved for people and the environment?
- How can the quality of life be improved for workers, my community and me?
- How can we change the potato chip system for a more sustainable future?

Example of a filled-in SDG Analysis Matrix

Potato chips: SDG-Analysis matrix			
SDG	Elements from your vision that contribute to the SDG	Elements from your vision that are counterproductive to the SDG	Make a note of any elements from your vision that contribute to one SDG but pose a problem for another SDG
	Increasing global markets for potato chips might generate incomes among the poor farmer communities		Worldwide increase of snack consumption may increase health problems
	Increase of potatoes as staple food will contribute to world food security		
		Processing of potatoes as unhealthy snacks will increase diseases in human society	
	Nutrition labelling helps the consumer to make informed decisions towards healthy food consumption		
			
		Increased cultivation of potatoes to match the demand may cause water shortages in high production countries or regions	
			

	Better working conditions and fair wages contribute to better living standards of farmers and labourers in the farming industry		Regionalisation in production might cause incomes to decline in specific sectors of countries that are leading potato exporters.
			
			
			
			
	Increasing potato production and packaging for snacking industries cause environmental problems, such as waste increase. The recycling of the package will cause CO_2 emissions	Increasing monoculture farming might lead to intensive use of soil and land.	
	More packaging waste will end up in the ocean		
			
			
			

STEP 7

IDENTIFY POTENTIAL POINTS OF INTERVENTIONS OF THE POTATO CHIPS SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Understand what a leverage point is in the context of the potato chips system,
- Understand there may be different leverage points with different efficacy within the potato system, and
- Apply the understanding about leverage points to potato chips systems to effect change.

2. Teaching approaches

Preparatory Activity

Let learners work in groups of four (two from the production line and two from the nutrition line).

In this step, they use the outputs from earlier activities:

- The outcome from the second part of the activity "We eat potato chips when...."in Step 1
- The concept maps developed in previous steps (or the comprehensive system maps provided in Step 3).

Activity 1 - Linking the production and nutrition sub-systems

Learners have to merge the two models of the system in one, connecting the production line with the nutrition line.

- Here are some leading questions to guide the merger of the two models.
- What is the bridge between the two systems?
- What influences the consumption of chips?
- Are the production and consumption of potato chips interdependent processes? If yes, how?
- Why do I want to eat more chips once I open a package?
- Is consumption related to production?
- List some tangible and intangible factors that link production and consumption. (For example, transport facilities and demand or advertisement).
- What is my (or an individual's) function in this system?
- How can I influence the production of chips with my decisions and actions?
- How does the consumption of chips affect my own health?

Activity 2 - Leverage points in the potato chips system

- Introduce the idea of a leverage point using the activities suggested in Step 7 (e.g., by showing the video extract from the movie Rush).
- Ask learners to identify potential leverage points in potato chips production. For this, a variation of the Jigsaw method may be used.
  - Present to the group the following question: How does marketing influence my consumption of potato chips?
  - Use the groups formed in the preparatory activity.
  - Each group should select a topic related to the question and discuss potential leverage points pertinent to the topic. They should prepare notes with their arguments to help them develop their conclusion. There are

many factors or topics that they can use. Here are some examples: Health, Cost, Working conditions, Marketing, CO_2 emissions (environmental factors), Consumption, Addiction (why do we eat them, flavour, social issue, convenience)

- Each group should nominate two participants who will become spokespersons and will leave the group and join the working group on the left. Their mission is to collect the information of the other working groups
- The two remaining participants in the original working group update the two new members and explain to them which leverage points have been identified in the topic selected. All the doubts should be addressed.
- This should be done until all the participants return to the original working group.
- At the end, each working group will have a holistic perspective of the topic and a set of the different leverage points of the potato chips system and would be able to answer the question.
- Each group should review all the information they gathered, integrate it to their Concept map and write a conclusion.
- Each group should present the changes they made to the concept map and their conclusion in a plenary.

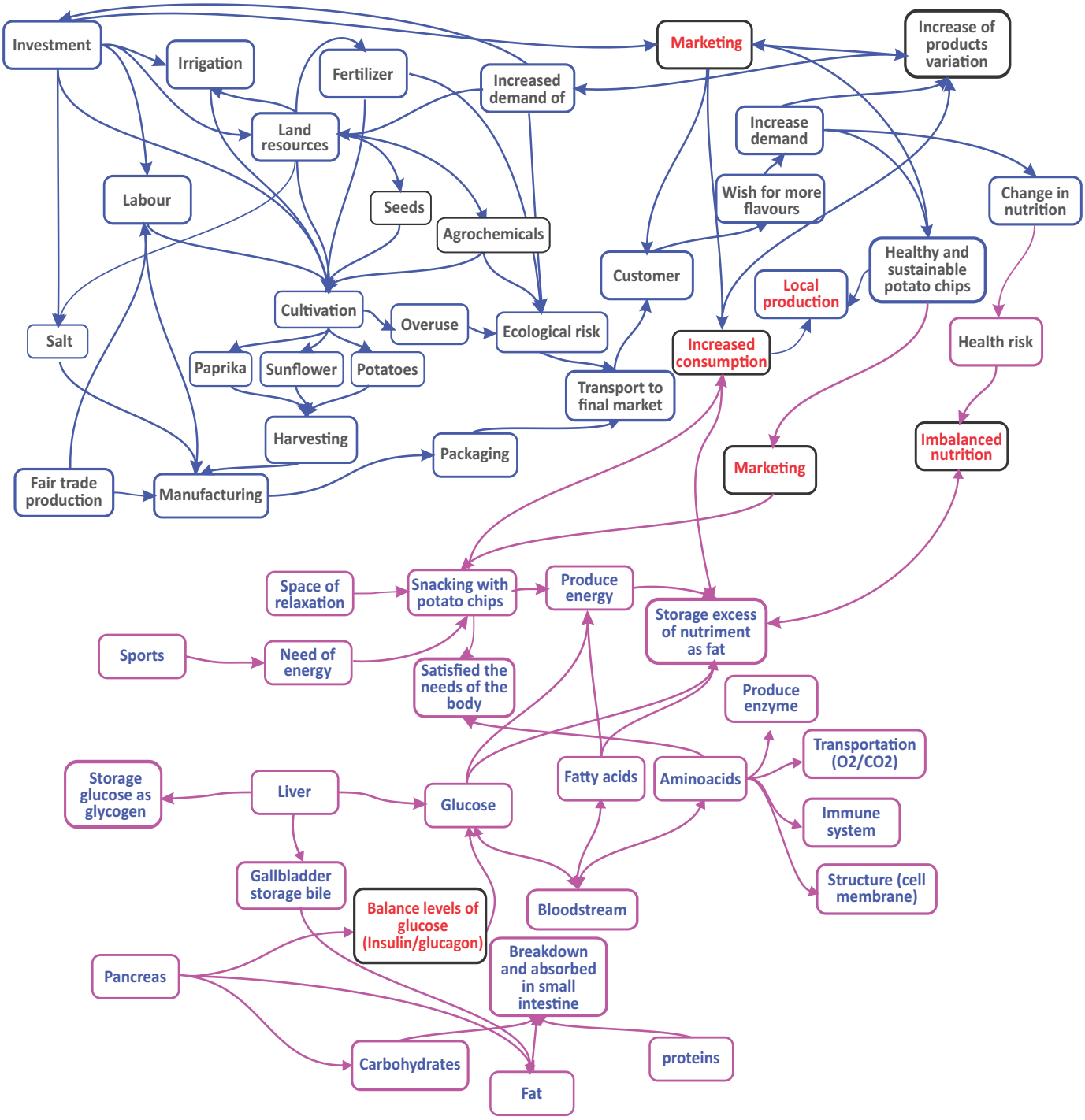
3. Further leading questions

- How to use points of intervention to achieve intended behaviour of the potato chips system?
- Are there possibilities for different types of interventions?
- Who decides that an intervention should be made, and with what aim?
- Which strategies/actions will be required to bring a change at a leverage point?
- Who can take such actions/decisions? If it's you, do you think you would be able to do it? If it is someone else, can you persuade them to act?
- What kind of intervention must be made at any leverage point?
- Are interventions to be done simultaneously at different leverage points?

Learning methods

- Group Jigsaw
- Mapping Technique: Concept Maps

Example of leverage points in the potato chips system



STEP 8

IDENTIFY POTENTIAL TYPES OF INTERVENTIONS IN THE POTATO CHIPS SYSTEM

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Understand that humans continuously intervene in many sub-systems of the global system, and therefore the global system itself,
- Understand that these interventions have been done, and are being done everywhere, knowingly, unknowingly, and often with partial knowledge,
- Understand that systems learning enables humans to decide and act to change systems, with purpose, and
- Use the knowledge about the points of intervention to change the functioning of systems.

2. Teaching approaches

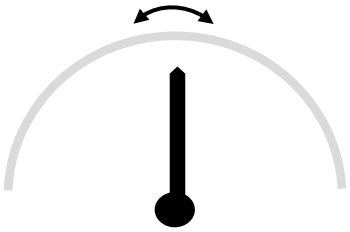
- Use the same working groups as in Step 7
- Invite the groups to identify different categories of leverages in their potato chips system. These might be used in different ways, causing different consequences. Ask each group to develop and present a podcast, of not more than 3 minutes duration. They should choose a leverage point in their potato chips system (model /concept map) and explain the expected results if different types of interventions are implemented.
- Ask learners to brainstorm and list different possibilities to act using the leverage point they identified. What are the different strategies to act? Learners may use the Worksheet: Sustainable or unsustainable from Step 6, as well as Worksheet: Using the Leverage.

Worksheet

Using the leverage

3. Further leading questions

- Can human beings change structures, goals/purposes and functions? What about natural laws?
- Is it possible to change the behaviour of a system in an intended direction, for sustainable development?
- If yes, how may this be done?



Example of leverage points in the potato chips system

Action/ Consequences	Leverage point	Action/ Consequences
No overuse of agricultural land • Limited yields. • stable or declining production. • natural soils. • recovering soil biodiversity. • good quality of groundwater. • ...	**Land resources used for potato production**	Overuse of agricultural land • Short term increase of yields • In the long run (permanent) degradation of soils may occur and farmers may need to make higher investments in agro-chemicals. • Water shortages. • Contamination of groundwater due to agro chemical overloads. • Competition between different agricultural activities on the usable agricultural land.
Weakening desire for more flavours • Declining demand on flavours • Maintenance of the current production • A fair income for workers • Support local production • ...	**Desire for more flavours of chips**	Stronger desire for more flavours • Increasing potato production • Economic growth • Increase in the number of big factories • Growing social disparities to be expected due to labour wages kept low and increasing wealth of entrepreneurs
Healthy and sustainable potato chips • Higher demand for healthy snacks. • Strengthening health programmes on community level. • Promotion of good performances.	**Marketing** Communication/ Social Media	Increase in consumption of the ordinary potato chips (business as usual). • Increase of snacking of potato chips • Relaxation is linked to potato chips consumption • Well-being is related to consumption
Change in the nutrition in school • Healthy snacks. • Learning about how to enjoy snacks within a good diet.	**Policy** **Nutrition in school policy**	Change in the nutrition in school • Snacks that exceed the recommended calories per day • Malnutrition
Clear production and nutritional information • Buyers know if the product is sustainable or not, if it comes from a Fair trade production. • Consumers know the ingredients and how appropriate they are for their daily diet. • Consumers can make an informed decision of what they consume.	**Labelling**	Unclear production and nutritional information • Information about bad calories is hidden • Misleading information is given • Artificial ingredients are included

STEP 9

GENERATE OPTIONS TO ACT IN THE FRAME OF SUSTAINABLE DEVELOPMENT

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, **generate options to act,** assess their impacts **in the frame of sustainable development,** and decide whether further actions are necessary or not.

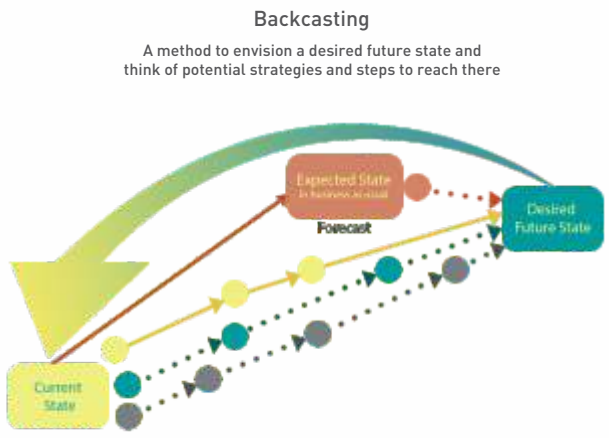
1. What is the aim?

To enable learners to:

- Reflect on unsustainable situations and decide on a desired future in the frame of SD for the Potato chips system,
- Apply the understanding of leverage points and their handling, to decide the interventions to achieve the desired future outcomes,
- Deal with potential dilemmas, and
- Prepare (and possibly carry out) a strategy to implement interventions.

2. Teaching approaches

- Form groups of no more than 4 participants. Groups formed in the previous steps may continue, or new ones may be made.



- Each group may work with one of the suggested questions or generate a new one with their future perspective of potato chips:
  - How can I enjoy potato chips without contributing to climate change?
  - How can I enjoy potato chips without promoting inequality in the world?
  - How can I enjoy potato chips without gaining weight/use as a healthy snack?
  - How can our community (or school) use/ produce chips as a healthy snack?

- The first task of the working groups is to collect and write inquiries based on the leading question. A typical way of asking for information is the "W"questions: when, what, who, with whom, where and why?
- Based on the main question and the information gathered in the group, the learners envision the future they would like to see and then prepare a written description or an illustration of this common vision of the future.
- Based on the vision of the future, the learners' groups may define the steps needed to achieve it. As the aim is to develop the steps to the future by going backwards, it is important to identify the steps from the future to the past (our present) as well as the main elements/leverage points to achieve it.
- Each group may discuss the order of actions needed to achieve the vision in a sustainable way. Encourage them to think about leverage points they can influence, not just as consumers but as active citizens who engage with the community and the government, and other stakeholders who require an external influence (politicians, factory owners, legislation, etc).

Learners are invited to analyse the differences between reality and the vision.

Learners present to the class, their vision of the future and the concrete steps to achieve it.

Learning methods

Backcasting

3. Further leading questions

- Is the vision really improving sustainability outcomes?
- What are the direct or indirect impacts of the intervention?
- Which one of the suggested visions seems to be the more sustainable to you? Why?

STEP 10

ASSESS POTENTIAL IMPACTS OF INTERVENTIONS IN THE FRAME OF SUSTAINABLE DEVELOPMENT AND DECIDE FUTURE ACTIONS

Systems thinking is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

1. What is the aim?

To enable learners to:

- Assess whether interventions in the system resulted in improved sustainability outcomes,
- Assess whether the choice of intervention in the system was appropriate to effect improved sustainability outcomes, and
- Decide if further interventions are needed.

2. Teaching approaches

Activity: SDG Analysis

System to be analysed: Future vision of potato chips design from Step 9.

Share copies of the Worksheet: SDG Analysis Matrix with the learners.

Their task is to review the vision of the future prepared in Step 9 and analyse which elements (actions needed) in the system contribute to a specific SDG or do not help achieve SDG targets. They should write their conclusions in the first and second column. In the third column they may identify and write any dilemmas that they identify between two SDGs – the situation where meeting some SDG targets becomes counterproductive for other SDG.

In case the action to achieve the vision of the future does not improve sustainability outcomes, learners would have to go back to Step 8 and analyse other leverage points of intervention to progress towards the desired common future.

Worksheet

SDG Analysis Matrix

Learning method

Analysis Matrix

3. Final, or further leading questions

- How do my actions impact the system?
- Which factor/leverage points am I not able to change and why?
- How can I influence the change in the leverage points that I cannot influence directly? What would be some concrete actions to achieve it?

EPILOGUE

EPILOGUE

Congratulations! We hope you have checked out the Ten Steps to Systems Thinking or tried the Jeans or Chips example. Perhaps you are thinking about using the systems approach to explore some new topics that interest you and your learners.

Looking Back

Competence enhancement

The aim of the 10 Steps is to enhance the learners' systems thinking competence. Various other competences for sustainable development (SD) are enhanced alongside. These are complementary to systems thinking competence.

A caution

As educators, we want learners to evaluate whether the systems they are considering can contribute to sustainable development and the 2030 Agenda, or otherwise. Professionals who consider business systems are usually concerned about the sustainability of their systems and not necessarily about sustainability of the larger environment in which those systems operate. While it is relatively easy to determine whether a system is going to sustain or not, it may not always be clear how a system may contribute to the larger sustainable development goals. Learners may gain such insight over time as they enhance and apply their understanding of systems and sustainable development in the real world.

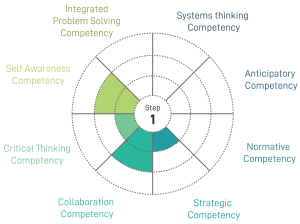
Your journey

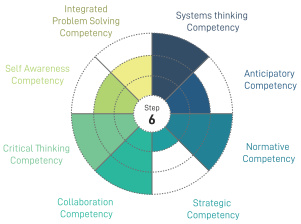
We wish you the best and hope you enjoy the journey of facilitation and learning about our immensely and endlessly fascinating, fragile, and precious Earth System.

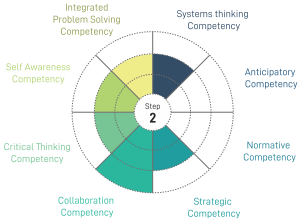
Stay in touch

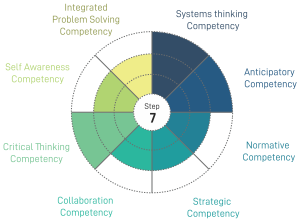
We are keen to know about your experiences of using this manual. We welcome questions and suggestions for improving the resource material, especially for its use in your social and cultural context.

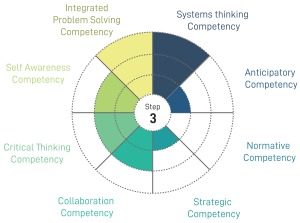
You may email us at systemsthinking@ceeindia.org.

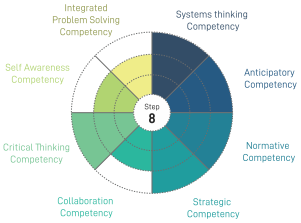


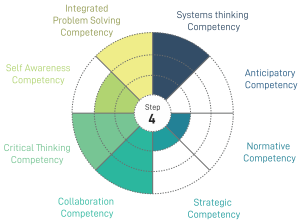


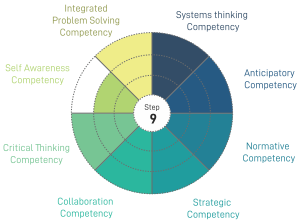


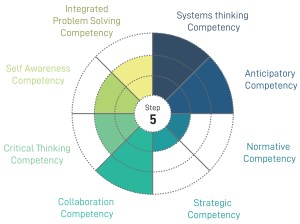


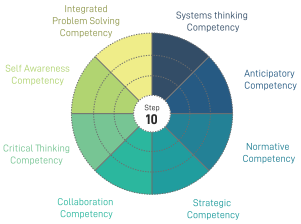












nur Mut	Los geht´s!	¡Empecemos!	Happy teaching	Auf geht´s!
Los gehen	¡Vamos!	Ready set go ...	Khuthazeka	शुभस्यशीघ्रम

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LEARNING METHODS

Advocatus Diaboli (The Devil's Advocate)

Suitable for Steps 3, 6, 7, 8, 10

Duration
15 to 45 minutes

Material needed
None

Group size
About 30. More effective if fewer than 25.

Objective

To develop and strengthen skills to discuss, debate and present a convincing case.

Description

The "Advocatus Diaboli", the Devil's Advocate, is a position either the teacher or a very well-informed and rhetorically strong learner can take in a discussion. The Devil's Advocate principally takes an "against" position. In the debate, he/ she will always be against the arguments presented and provoke the other debaters. In doing so, he/ she trains them to discuss clearly, convincingly, and present rhetorically more robust arguments.

Initially, to stimulate debate, the teacher or facilitator may encourage the expression of a wide range of views. From among broader ideas, further vivid and controversial debate can help identify positions and lead to a second round of thinking and imagination of causes and consequences. Eventually, facilitation may guide the learners or participants to examine values underlying different positions. The facilitator needs to take care to eventually de-personalize positions and views from individual participants.

Examples of topics for debate

- Potato chips should be abolished for improved health.
- There should be widespread use of GM (genetically modified) seeds to increase cotton production.
- Drinking water supplies may be diverted to increase cotton production.

Contribution to Systems Thinking competence

The exchange of arguments enhances the individual and collective understanding of a chosen topic. Individuals are exposed to other points of view and have an opportunity to examine their opinions and understanding.

Analysis Matrix

Suitable for Steps 2, 3, 6

Duration
up to 1 hour

Material needed
Paper and pen, or a photocopied worksheet

Group size
Individual, partner, or groups of four

Objective

To analyse complex structures to detect correlations and dimensions, which enable a better understanding of complicated topics.

Description

The content to be analysed may be text, video, audio, numeric data, or other forms.

"Analyse the world cotton market!" could be a suitable task to give to the learners while working with the example of the Jeans system.

The learners will first have to think about various factors associated with markets, such as supply, demand, goods, customers, etc. Next, they may be able to identify qualitative aspects such as capital flows, profits, losses, environmental advantages or disadvantages, or workers' health, just to name a few.

An analysis matrix, which combines quantitative factors with qualitative aspects, can help learners obtain a systematic overview of the topic. By filling the fields, the learners analyse the cotton market as instructed and simultaneously develop a values perspective with which to judge the market.

Contribution to Systems Thinking competence

The learning method helps to comprehend a complex topic by dividing it into smaller bits. The framing of the "conclusion" brings the smaller bits together in a structured description that reflects the complexity of the topic. The acts of analysis and synthesis help in grappling with complexity.

Example

"What actually causes actual global warming?"

To answer this question, one needs a detailed knowledge and an assessment of individual factors within the complex system "climate".

The first step is to prepare a matrix (refer table below) that suits the topic.

Scientific information will help learners to fill the analysis matrix.

Writing the 'conclusion' helps learners present their synthesized understanding of the causes.

	Yes, because ...	No, because ...	Yes, but ... Or, No, but .... Or remarks on any uncertainty
Position of the earth relative to the sun			
Intensity of solar radiation			
Ice coverage			
Composition of atmospheric gases			
Conclusion			

Back-to-Back Sitting

Suitable for Step 1

Duration
30 minutes

Material needed
Sheets of blank paper (at least 2 per pair), pens or pencils, erasers
A collection of objects, pictures or names of items written on small cards

Group size
Up to 30 in pairs

Objective
To strengthen the learners' ability to prepare structured, detailed, and correct descriptions.

Description

1. Ask each pair to sit back-to-back on two chairs.
2. Distribute the objects (or pictures or name cards) to the pairs, one per pair. Give the object to only one person in each team, without telling the other member of the pair what it is.
3. The one who receives the object must describe it to the partner without naming it.
4. As the partner hears the description, he/she should draw on paper the item being described according to the understanding gained from the oral description. After completing their description and drawing, the pair can sit together and compare the actual object with the drawing prepared.
5. With this experience, they reflect on the ability to describe correctly and trace their progress with repeated rounds.

How the learning method Contribution to Systems Thinking competence
Preparing a detailed description of a topic helps to clarify and present ones' understanding of the topic.

Example

The drawing of a field with flowering cotton plants according to the description of the learning partner will open the eyes of both learners for a blue sky, barren surrounding, an ordered arrangement of plants, their identical heights, the colour of their blossoms, parts of the irrigation system including canals and pumps, and much more.

Based on such a detailed description and the resulting drawing, the learner will be equipped to ask further leading questions, to understand the reality of the topic more deeply.

Backcasting

Suitable for Steps 7, 8, 9

Duration
1 to 2 hours

Material needed
Writing materials

Group size
Pairs or groups of four

Objective
To enable learners to develop realistic working plans for intended changes in the future.

Description

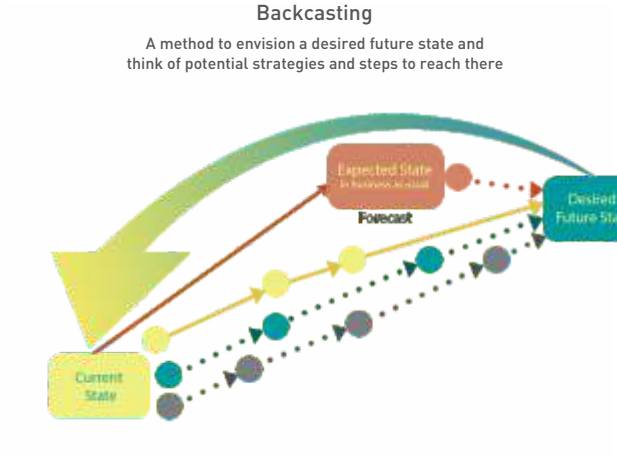
Backcasting is a planning method that starts with defining a desirable future and then working backwards to identify policies and programs that may connect that specified future to the present.

Starting from this future scenario, you will think about the various conditions that would be in place at the point. Then keep working further backwards (to the present time) to realistically plan the nature of the steps to be taken as well as the strategy to take these steps.

Note that backcasting is different from forecasting. In forecasting, the idea is to use current knowledge and trends to predict what will happen in the future. In backcasting, the approach is to envision the future, and ask what actions must be taken to get there. Backcasting and forecasting may be used in a complementary manner.

Contribution to Systems Thinking competence

The learning method is helpful to develop visions of an intended future and the strategic steps to reach there (in time). This is the contribution of the learning method to improve systems thinking competence.



Example

If the intention is to produce only organic cotton by say 2030, then you start from that intended reality in future and think backwards about what you will have to do to reach this state. Alternative materials, dyes, cloth markets and many such aspects have to be considered and arranged in a logical time frame.

Further Resources

Sustainability Illustrated (Jan 22, 2014). *Sustainability Strategy: Backcasting from Success.* [Video]. https://www.youtube.com/watch?v=DeDm-HTFuiY

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Behaviour over Time Graphs

Suitable for Steps 4, 5

Duration
1 to 2 hours

Material needed
Writing materials

Group size
Individuals, pairs or groups of four

Objective

To enable learners to:

- understand trends and projections,
- focus on patterns of change over time rather than on a single event, and
- think about the underlying causes of those changes.

Description

Often, it is only when situations become alarming that we recognize them as problems. Changes over time and patterns of changes may not be adequately recorded and considered while making day-to-day decisions.

Some of the system feedbacks may surface after a long period of time. That is, an action taken now may have an effect sometime in the future, and not immediately. However, if changes are studied over time, they can help us focus on patterns of change over time rather than on single events. They help us think about the underlying causes of those changes.

Behaviour-over-time graphs (BoTGs) show how an element changes over time. The one important aspect to remember about a BoTGs is that "time" must be plotted along the horizontal axis. The "behaviour," of the element that changes over that time, is plotted on the vertical axis. The purpose of the graph is to picture how the behaviour changes as time progresses. Time can be in any unit that fits the behaviour: seconds, hours, days, years, etc.

The Variables

The behaviour can be anything that increases or decreases over time. For example, it can be the amount of money in a bank account left to accumulate interest, water level in a well, the number of bamboo clumps in a given area, or the number of livestock or people in a village. In these examples, currency units, metres, and numbers of clumps, livestock or people are plotted on the vertical or y-axis.

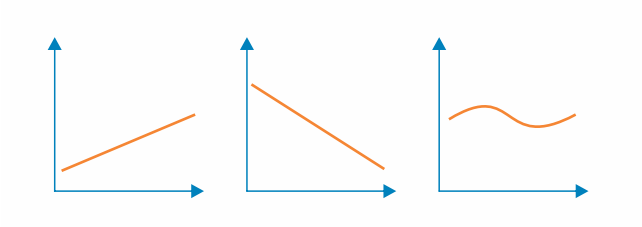
However, there are also many other important variables which increase and decrease over time but which cannot be measured in conventional units such as currency units or metres. For example, the enthusiasm of a football team in a game.

These "soft" variables can also be plotted and examined by discussing and deciding the scale on the vertical axis. So, if the enthusiasm of a cricket team could be thought of as highest at the start of the game, it then could be thought of as the high range and depicted by the number 10.When the defeat of a team is certain, that point could be thought of as the lowest of the range and assigned the number 0. Alternatively, these points could be defined as "Low," "Medium," and "High". The same idea applies to all

other variables that do not have conventional measured units.

A BoTG can be used to plot and explore any change.

Unlike the typical graph, divide the BoTG X-axis in two sections. In the first section plot the current observations or perceptions. In the second, the trend in the future can be continued as different alternative scenarios: what is expected or predicted, and what is desirable to see happening in the future. There can be alternative scenarios or trend-lines for different predictions.



BoTG can be used in any curriculum area to support learners think more deeply about what they have learned, whether it is a story in literature, a topic in social studies, or a science experiment. In any case, it helps to lead learners through a series of steps in the discussion until they develop this thinking skill on their own.

These are questions to guide the graphing and the discussion:

1. **What is changing?**

   If you look at the story or the historical developments or the experiment, what is changing over time? What is going up or down?

   - Brainstorm a list of changes and write them down. Learners may generate several variables, both hard and soft.
   - Ask learners to look for the underlying currents of change rather than just the events. What do they see increasing or decreasing with time?
   - From the list, focus the discussion on those variables that are most important and central to the issues you want the learners to explore.
   - At first, you may want to choose one variable to graph together as a group. Or, you might ask learners to work individually or in groups on either the same variable or several others.

2. **How is it changing?**

   Help learners to draw their graphs and make sure that they depict what they want them to say. For example, if they say something is going up, the line on the graph needs to be going up. This may take practice for some learners at first.

   - It helps to define the axes together. How long is the time? What is the variable and what do low and high values of it mean?
   - Once a graph is drawn, learners should look at the line on the graph. Is the variable going up or down? Is it changing rapidly or slowly? Does it start out in one direction and then change direction? Does it level off or keep fluctuating?
   - The idea is to identify the pattern of the behaviour, not every little detail. Learners are learning to "read" the graph and think about the change it describes.

3. **Why is it changing?**

   Next, learners start to think about the behaviour itself. If something is going up, what is happening in the story or experiment to keep it going up? Why did it start to speed up, or go down, or level off? Try to look within the system itself for the causes of the behaviour. For example, a population would keep growing more quickly because as people have children, those children have their own more children, and so on, until it becomes too crowded and the growth levels off.

   Further questions to help learners think about how the variable's behaviour over time fits into the system it is it part of:

4. **Why is the change important?**

   What difference do these changes make to the rest of the story? How could it have turned out otherwise?

5. **What are the relationships?**

   What are the most important variables and how do they relate to one another?

   If learners plotted more than one variable, how do their graphs compare? Does one rise as the other falls, for example? If you plotted only one graph at first, does it suggest a graph of another variable? The idea is to see how the parts of the system fit together, to think about what causes what.

6. **System structure and behaviour**
   The behaviour of a system depends on the way the system is organized. See different visualisations of systems behaviour varying over time.

Contribution to Systems Thinking competence

BoTGshelp us to understand the structure of systems and vice-versa. They can help to look for patterns of change and try to understand their causes. When trying to understand the behaviour of a system, learners should have enough time to explore the "Why" in depth. The goal is not just to draw a graph but for learners to think this way!

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- Kirkwood, CW. (1998). *System Dynamic Methods: A Quick Introduction.* Arizona State University. CC BY-NC-3.0 https://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/SDIntroduction.htm

Brainstorming

Suitable for Steps 1 and 2

Duration
30 to 40 minutes

Material needed
Writing materials

Group size
Individual, group of up to 20 to 25

Objective
Enable learners to gather key ideas and associations around a topic.

Description

Brainstorming helps learners gather their thoughts and information on the chosen topic and evolve new ideas through discussion. The person or group brainstorming writes down all the facts that come to mind. The emerging collection of words, phrases, and sentences, document their existing knowledge of the topic. At the same time, it can show the gaps in knowledge. The difference can help learners think about the known facts and order them logically. The association of words and ideas can jog the learners' thinking and add new ideas, which they might not have thought otherwise.

The steps are:

1. Write everything down just as it comes to mind, in no particular order.
2. Alternatively, first, think about categories or broader terms; in this case, they may be like "raw material", "components", or "processes". This provides a certain order to the brainstorming. Note that some may find that providing an order helps jog their thinking, while others might feel that providing an order or structure too soon constrains their thinking. In Brainstorming, it may be advantageous to first enable broader and more divergent thinking, before collating and structuring the ideas.
3. Arrange the words, phrases and icons in a structure that is meaningful and present it in the forms of a graphic.

Contribution to Systems Thinking competence

Brainstorming is an important method to get a broader understanding of the different aspects of a given topic, jog one's thinking and create new thoughts in relation to a topic. Brainstorming is akin to listing several different elements that may be present in a system and allowing one's brain to lead on to different elements through a natural process of association of words and ideas.

Example

Assume that the task is to answer the question "Can we eliminate usage of cotton in our lives?".

Before answering this question, one might first think about all the goods that are made of cotton. A brainstorming would be very helpful and bring up keywords like T-shirts, jeans, jackets, skirts, gunpowder, explosives, bandage, hygiene items, ropes, notes, etc.

Cinquain

Suitable for Step 1

Duration
30 to 40 minutes

Material needed
Writing materials

Group size
Individual

Objective
Prepare short, interesting descriptions of selected nouns (topics)

Description

1. Explain to the participants that a cinquain is a poem in 5 lines, and that the word cinquain comes from the Frenchword 'cinq' for "five."
2. Share the formula or recipe for writing, as below, and ask the participants to develop their own poems and read them out.
3. Note that the cinquain has five lines that follow this sequence:

   Cinquain Recipe

   Line A: One general one-word subject or topic
   Line B: Two vivid adjectives that describe the topic
   Line C: Three interesting -ing action verbs that fit the topic
   Line D: Four-word phrase that captures feeling about the topic
   Line E: A very specific term that explains Line A
4. Ask learners to try their hand at writing cinquains. Let them present to the class.

Contribution to Systems Thinking competence

The Cinquain may help learners to develop first descriptions of several elements of the chosen topic, in an interesting and engaging way.

For example, learners may list several different dimensions of 'Cotton', such as cotton pest, organic cotton, jeans, etc. Learners working individually or in groups could quickly prepare several short rhymes that get them thinking about these topics in a little more detail.

Example
Insect
Hidden, hungry
Preening, searching, stalking
Waits as if praying
Mantis

Debate

Suitable for Steps 9, 10

Duration
30 minutes to an hour

Material needed
None; or podium in case it is available

Group size
A moderator, as many groups as there are major viewpoints (two to three) and one speaker to represent each group.

Objective
To arrive at a decision or conclusion about the topic of discussion.

Description

A debate is not the same as a discussion. While discussions are generally open and without strict rules, debates are regulated with regard to the time allotted for speech and the sequence of speakers.

Debates are used to arrive at a decision, often through voting, after assessing the arguments made for or against the topic. The arguments though mainly expected to be rational and backed by facts, may also have a values-based argument or emotional appeal on the controversial issue.

A debate must be conducted with appropriate preparations. The debate is headed by a moderator, who guarantees the rules including that each speaker can express his thoughts without interruption.

To conduct a pros-cons debate, two groups are placed opposite to each other. Each group names one member as their speaker.

Preliminary steps:

- Get well informed about the topics, including pro and cons positions.
- Summarize your main arguments in written form.
- Train for articulating your arguments in a practice session.
- Make your arguments transparent, example by depicting on a poster or digital media.

- Get your arguments well prepared with the help of group members.

The debate:

- The moderator opens the debate with a short summary of the topic and reminds the participants about the rules.
- Each speaker makes his/ her plea in a maximum time of three minutes.
- After the statements both groups discuss among themselves the possible strategies and arguments against the other position.
- The moderator opens the core phase of the debate allowing both speakers to exchange arguments.
- The moderator integrates the audience into the debate by putting questions to the speakers.
- A final voting shows a clear result of the debate and the conviction of the majority.

Contribution to Systems Thinking competence

Different views about sustainability may arise in relation to an issue, for which a decision is needed. A debate allows for a platform where strong arguments can evolve, based on which voting can be conducted, or for which a consensus may emerge.

For example, whether the use of genetically modified organisms (GMOs) is acceptable is a topic of debate. A debate can help evolve public policies.

Training for clear articulation of one's views, thinking logically, and being able to grasp opposing viewpoints and consider them fairly, are important democratic skills. The assemblage of different points of view, the underlying rationale and values are part of developing a systemic understanding of issues.

Explainer Videos

Suitable for Steps 4, 5, 6, 7, 8, 10

Duration
Minimum one hour

Material needed
(Smartphone) camera, paper, folio, colour pens, scissors, white table

Group size
Not more than four

Objective
To strengthen the scientific understanding of learners, the creativity as well their verbal skills.

Description

The learning method focuses on creating a video to explain a complex topic. The specific character of an Explainer video is the narration of the topic while using simple drawings of the elements, fashioned as cut-outs, to illustrate the points made in the script.

Learners may prepare such a video by arranging a (smartphone) camera over a white desk and recording the narration. One student may place the cut-outs of the elements on the table as the explanation proceeds and manipulate the cut-outs, if needed, to explain the points. The pictures appear and disappear according to the progress of the explanation.

The learners will need to:

1. Prepare an outline of how the video will run to explain their topic.
2. Prepare the script and the storyboard, that is sequence of the graphics or illustrations that will tell the story. They should try to make their narration crisp and keep the videos up to 3 to 4 minutes in duration.
3. Draw all the relevant elements of the topic on paper and then make cut-outs according to their shapes. (Students may also prepare a slideshow with these graphics).
4. Video record their explanation using the cut-outs.

Contribution to Systems Thinking competence

The experience of developing the script and visuals helps learners to synthesize their learning and thinking and contributes to developing systemic competencies. In addition, the substantive content collected and communicated using this method adds to the learners' individual development.

Examples

In the context of the systems thinking steps, learners may explain, for example:

- Concepts of sustainable development
- The world cotton market
- Biological processes in the human body after eating chips.

See the Explainity YouTube channel and website for examples
https://www.youtube.com/channel/UCOo8aKrwtWmlLUEpatJ2nyg
https://www.explainity.de/

Future Workshop

Suitable for Step 8 and 9

Duration
1-3 days

Material needed
Prepared documents or presentations on the topic as a basis for the method

Group size
Up to 20 per group

Objective
To develop ideas for the future of a campus, neighbourhood, city or region by jointly considering problems, challenges and potential solutions.

Description

Broadly, the process organizes a workshop for "thinking about our future". The learning method has three main steps.

Stage 1 The phase to critique

Participants discuss the reality of the topic they are working on. For example, with 'cotton' as the topic, the question could be: How is the world cotton market to be characterised? If the learners find out that the cotton production and trade system have low wage labour, environmental pollution, severe health problems due to agro-chemicals, unfair trade conditions etc. they should judge the reality as problematic, which has to be reformed.

Stage 2 The fantasy phase

Learners think and develop without any limits, a future that surmounts the recognized or known problems. It is up to them, what they create and how they shape the future, whether it is an even more technical, or a strictly sustainable future.

Stage 3 The realization check

All the suggestions are discussed. Each idea is assessed for whether there is a realistic possibility to realize it. To use the cotton example again: a suggestion could be to produce less, but eco-friendly cotton, pay higher wages to the workers and charge for the guarantee of the biodegradability of the products. This is not an unrealistic scenario.

The overall idea of the learning method "Future Workshop" is to open a space where unthought or undiscussed ideas can come up and therefore might open new insights into topics that are assumed to be well-known and well-understood.

Contribution to Systems Thinking competence

The method helps learners to:
- Identify a new vision of the future
- Combine their understanding of the dynamics of the system
- Explore how changes in single factors of the system may help to reach the vision

A helpful combination for the next step might be the use of the learning method Backcasting.

Group Jigsaw

Suitable for Steps 6, 7, 8, 10

Duration
1 to 2 hours

Material needed
Information on the topic, tables, signages for basic and expert groups

Group size
12 or 24

Objective
To help learners develop the ability to cope with complex tasks by taking individual responsibility, relying on each other, working cooperatively to achieve results.

Description

This learning method is most appropriate for a topic that can be divided into a set of sub-topics that would take approximately the same time to discuss.

Initially, you may give the learners a complex question, which none may be able to solve on their own. For example, 'which strategy is the most successful for achieving sustainability?' As they respond to the question, help the learners recognize that there may be various strategies that may be assessed and compared. (The answers to the question might be, for example, education, taxation, clean energy).

The activity hereafter proceeds as group work in two rounds: 'Strategy' groups are formed in the first round. In the next round, one member from each strategy group is drawn out to make 'Specialist' groups. The number of participants of each group should be the same as the number of subtopics to be discussed.

Procedure

1. Ask a complex question to the whole group. Let the whole group brainstorm for a few minutes. Consolidate the responses into sub-topics.
2. Form strategy groups and ask each group to allocate one sub-topic to each member in their group.
3. Dissolve the strategy groups and create the specialist groups.
4. The Specialist groups consist of one member from each strategy group. They each work on one subtopic, conducting group brainstorming, internet search, etc. After the Specialist groups discuss their sub-topic, dissolve them
5. Ask learners to form the original strategy groups again. This time, the members share the specific knowledge gained from the specialist group they were part of and discuss the original complex question using their expert knowledge.
6. Finally, each strategy group may present a slide show, poster, or speech, to the plenary.

Contribution to Systems Thinking competence

The learning method group jigsaw is well-suited to develop systems thinking competence as it facilitates cooperative ways to deal with complex topics. There is a rapid growth in ideas due to the structured flow of information between and among groups.

Example

Use group jigsaw method for questions like:

- Which is the most sustainable strategy to meet the increasing demand for cotton jeans/ potato chips?
- Which country copes best with the challenges of sustainable cotton jeans/ potato chip production?

See the illustration to understand how the groups work. The left most image is like the initial Strategy groups. The middle image depicts the Specialist groups with a member in each group, from the basic Strategy groups. The right-most image depicts the Strategy groups again.

Group Jigsaw

Indicator Eggs

Suitable for Step 6

Duration
60 to 90 minutes

Material needed
Copies of 'EGG', one per group.
Copies of Case Studies

Group size
4 to 6 per group

Objective
To use indicators in assessing progress towards Sustainable Development.

About indicators

How do we know if we are making progress towards Sustainable Development? The starting point for answering this question is a worldview that shows the relationship between human societies and the ecosystem.

One model comprises people within the ecosystem. It also includes the interactions between the people and the ecosystem. The interactions consist of flows from the ecosystem to people—both benefits (life support, economic resources, etc.), and stresses (natural disasters); and flows from people to the ecosystem—both stresses (resource depletion, pollution, etc.), and benefits (conservation).

People depend on the ecosystem surrounding and supporting them, much as the white of an egg surrounds and supports the yolk. A healthy ecosystem is no compensation if people are victims of poverty, misery, violence, or oppression. Just as an egg is good only if both the yolk and white are good, similarly a society can be healthy and sustainable only if both people and the ecosystem are in well-being. Human well-being is the main quest of sustainable development. Ecosystem well-being is a requirement because it supports life and is the basis for good quality of life. Both human and ecosystem well-being are equally important, and a sustainable society needs to achieve both together. The goal for every society is thus to improve and maintain the well-being of people and the ecosystem. How can we know if we are moving towards this goal?

For this, we will need indicators.

An Indicator is a pointing or directing device. It is an instrument that indicates the condition of something. For example,' body temperature' is an indicator of health. The 'Intelligence Quotient', or IQ, is an indicator of intelligence. The Gross National Profit (GNP) is an indicator of the wealth of a nation. The percentage of children in school is an indicator of education.

We can use indicators at different levels. Some are used at the individual level and indicates us about the well-being of an individual. For example, the weight and height of a baby in relation to its age indicates its nutrition and development status. The BOD (Biological Oxygen Demand) is an indicator of the health of a water body.

Some indicators are applicable at the community level. For example, the percentage of children attending school is an indicator of literacy in a village. The area of degraded village common lands is an indicator of the well-being of the environment of that village.

Some indicators are used at the national level. For example, the life expectancy of people in a country is an indicator of health status. The forest cover is an indicator of the well-being of the environment of a nation. Indicators can tell us how society is progressing towards the goal of Sustainable Development.

Every indicator sends a signal: the more indicators we have, the better the assessment we will make.

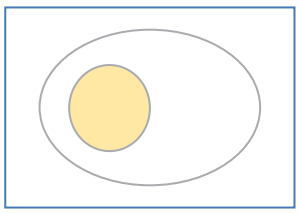
In Step 5, the indicators considered are:

- Human Development Index, to assess human well-being
- Ecological Footprint, to evaluate the environmental impact

Preparation

For this activity, you will need to do the following:

1. First, make 'Eggs' - one for each group: Cut a white piece of paper in the shape of an egg. It can be about 10 cm tall and about 5 cm wide. Refer to the illustration given. Next, cut a circle of yellow paper (about 3 cm in diameter) and stick it on the white paper as shown.



2. Copy the following case studies. Give one case study each to a group of 4-5 participants.

Description

a. Divide the participants into four groups of about 4-5 participants each. Give one case study and one 'egg' to each group.

b. Tell the groups that the egg has two portions: one white and the other yellow. The yellow portion represents the well-being of people. The white part represents the environment that supports and sustains people.

- Only when both the white and the yellow portions of an egg are healthy, is the egg good or fine.
- If any one of the portions is spoilt, the egg is spoilt.
- Similarly, only if both the environment and the people in it are in a state of well-being, is the system fine. On the other hand, if any one of these is in an unsatisfactory state, the whole system is not in a state of well-being.

3. Tell the groups that in this activity, they will use the eggs to indicate the well-being of the places mentioned in their case studies.
4. The first task for each group is to read the case study and discuss it among themselves.
5. Ask the groups to look out for information in their case study that will tell them about the well-being of the people. The participants may use specific indicators from each case. For example, the health worker of Viratpur says that nearly half of Viratpur's population has some gastro-intestinal problem at any point in time. The woman of Shantinagar says that she is on the Panchayat (selected village committee) and takes decisions along with the male members. These bits of information from each case study 'indicate' to us the well-being of the people. They are indicators.
6. If the group feels that, in their case, the people are in a state of well-being, they leave the yellow portion of the egg as it is. If they think that the people are in an unsatisfactory state (that is, if they are poor, uneducated, have threatened livelihoods, bad health, etc.), they colour the yellow portion according to the severity of the problems. For example:
   - Severe - Black (solid colour with a pencil)
   - Serious - Grey (heavily shaded with a pencil)
   - OK, but danger signals - lightly shaded with a pencil
7. Similarly, they also have to look out for information in their case study that will tell them about the well-being of the environment. For example, the housewife in Megatta mentions a haze that wraps the city in the evening. The child from Shantinagar mentions huge trees, birds, squirrels, and other animals near the village. These bits of information 'indicate' the state of the environment.
8. If the group feels that the environment is in a state of well-being, they leave the white portion of the egg as it is. On the other hand, if they think that the environment is not in a state of well-being (that is, if it is degraded, polluted, etc.), they colour the white portion according to the same criteria they used for the yellow portion.
9. Give the groups 30 minutes for this activity.
10. Ask one representative from each group to show the group's egg. The representative should read out their situation and present/justify why they have coloured their egg as they have.

Discussion

1. How many eggs represent systems which are in a state of well-being? How many are in an undesirable state? Why?
   - In the case of Viratpur, both the people and the lake are not in a state of well-being. The people are unhealthy, uneducated, and poor. They also do not have facilities such as sanitation and water supply. The lake is polluted.
   - In Megatta, the people have good facilities (water, electricity, communications, etc.) and enjoy a high standard of living. But this may not last for long, as per the view of the municipal officer. The environment is not in a state of well-being.
   - In Adilapur, the environment seems to be in a state of well-being with a rich diversity of species. But the well-being of the people is a problem. They do not have access to resources, and their livelihood is threatened.
   - In Shantinagar, both the people and the environment seem to be in a state of well-being. Both the men and the women participate in securing facilities (school, health centre, wells, etc.) for themselves. They have also managed to conserve their environment and use resources wisely.

2. What information about your city/ village would give an idea about its well-being?

   Ask the participants to brainstorm and list indicators for their city/village for human well-being and environmental well-being. For example, will the number of trees be an indicator of the well-being of the environment? Will the number of bus stops be an indicator of the well-being of the people? They should try to list at least ten indicators for human well-being and ten indicators for environmental well-being.

Contribution to System Thinking competence

This method provides a way to understand the behaviour of a system and its sub-systems from multiple points of view. In this case, a simple sustainability framework of human well-being and environmental quality. The behaviour a system may be assessed against the desired goals of human well-being and environmental quality.

Case Studies

Case study 1: Viratpur

Viratpur is a small community located along one side of a lake. Here is what the people of Viratpur say:

- Man - Ours is a poor community. Most of the men here work as daily labourers, guards or office helpers. Most of the women also work but as domestic help in apartments on the other side of the lake. What else can we do? Less than twenty of us have been to school. Even today, only about twenty children from Viratpur go to school.
- A person living in an apartment across the lake - The people of Viratpur are a nuisance. They use the lake shores for their toilet needs! They even dump garbage on the lakeshore. The whole place stinks. I heard that about five years ago, the lake used to be
- home to many water birds. But now you hardly see any birds here. From time to time, we see dead fish floating on the lake surface. Even fish can't live in a lake that is so dirty.
- Health worker - Nearly half of Viratpur's population has some gastro-intestinal problem at any point in time. This is only to be expected. Very few houses have water supply. The rest take water for drinking, cooking and other daily needs from a bore well close to the lake. Less than one-fourth of the houses here have toilets. Malaria is another problem increasing in its seriousness. Moreover, the shallow waters along the lake edges have become a breeding ground for mosquitoes.

Case study 2: Megatta

Megatta is a large and fast-growing metropolitan city. Here is what the people of Megatta have to say about their city:

- Traffic Policeman - I think the number of vehicles in this city is growing by the hundreds each day. So naturally, there is also an increase in the air pollution levels in the city. I have been a traffic policeman for the past seven years. I do not like the work, but I get a reasonable salary, so I can't leave it either! I have severe bouts of cough, and the doctor says it is because of my exposure to vehicular smoke.
- Housewife - Our city has many facilities that several other cities do not have. For example, we have piped cooking gas that comes right into the kitchen, so no trouble waiting for gas cylinders. We also have good telephone connectivity, uninterrupted water supply and electricity. The only problem is this haze which wraps the city in the evening. It is terrible. It is difficult for us to see even five metres ahead of where we stand in some places.
- Senior citizen - This city is dying. The younger folks think that it is one of the best cities in the country, but they have not seen the city in its earlier days. What is left of the city's past glory today? The lakes that dotted the city have been drained to build apartments. Trees have been cut down for timber and for making roads. There are hardly any green lungs in the city, and you can see the result—the city is choking!
- Municipal Official - We try our best to serve the city, but it is a challenging job. The number of people in the city is increasing each year, but our civic facilities cannot keep pace. How many more houses can we build in this limited space? Where will we get clean water to supply to all citizens? How and where will we dispose of the wastes that these people create? Today things may seem alright, but tomorrow will be a problem!
- A young man - This city is simply amazing! The standard of living is high. Nowhere in the country will you get well paid jobs? The shopping places, public transport facilities, schools and entertainment places are all great! This city is full of life and never seems to sleep!

Case study 3: Adilapur

Adilapur is a tiny hamlet bordering a famous national park. Here is what the people of Adilapur have to say:

- Headman - Life is miserable here. Our people are not allowed to enter the forest at all. We have been dependent on the forest for generations—for fuel-wood, fodder, medicinal plants, fruits, etc. Now they (government) have declared it a National Park and say we cannot enter it or use it. What do we do now?
- Woman - I used to go to the forest each day to collect firewood. Now the forest guards drive me out whenever they see me. If I do not collect firewood, how will I light the stove? Earlier I was free to go into the forest. I could also collect small fruits and roots. These would help my family survive when the crops failed.
- Farmer - Farming on the edge of the jungle is not an easy task. First, there is very little land available for farming. That too is under the threat of being
- swallowed by the national park that the government plans to enlarge. Secondly, deer from the forest are a big menace to our crops. They come in herds and feed on crops that are waiting to be harvested. All the hard work we put in for months goes to waste! A bigger problem is with the big cats in the jungle—the tigers and the leopards. They attack our cattle and goats. We are not allowed to harm these animals because they are 'protected animals'! Who will protect our crops and cattle?
- Forest Officer - This national park is one of the richest places in the country in terms of the variety of plants and animals found here. It is also home to some very rare species of plants and animals. We have been protecting the park strictly night and day. Unfortunately, people from the nearby villages sometimes try to enter the park illegally and take away wood and grass. They seem to be ignorant about the fact that this park is a national treasure.

Case study 4: Shantinagar

Shantinagar is a small village. Here is what the people of Shantinagar say about their village:

- Community elder - We are a community of about fifty households. All adults in our village participate in making decisions. That is how we managed to do so much—start a school and a health centre, dig wells, etc. We are a peaceful community. During festivals, we organize dance and song each evening under the huge neem and banyan trees of the village.
- Woman - I work in the fields and at home. I am also an elected member of the Panchayat (elected village council) and take decisions along with the male members. I initiated the Panchayat to make two major decisions – one is that, all children in the village must go to school and secondly, that no tree in the village should be cut down without permission from the Panchayat.
- Man - I am a farmer. I also manage the village fuel-wood plot. I make sure that people do not steal wood from the plot. We harvest only the required amount of wood at specific times and distribute it to all villagers. The Panchayat pays me for protecting the plot.
- Child - I love playing with my friends near the lake next to our village. It is cool and breezy there. There are huge trees where we put our swings. We also see lots of birds, squirrels, mongooses and turtles there.
-
- From 'Towards a Green Future: A trainer's manual on education for sustainable development', developed and published by Centre for Environment Education, Ahmedabad, India.

Internet Research

Suitable for all Steps

Duration

As per need

Material needed

Internet and a suitable device (laptop / desktop / tablet / mobile phone etc.).

Group size

Individual or in small groups.

Objective

Acquiring the skill to look up/search for relevant information on the internet.

Description

This learning method requires learners to collect relevant information by searching the net. In this changing world this teaching method is the most useful academic tool and can be used in all the 10 Steps.

It is critical and crucial for learners to have the required skill in navigating the internet. Learners can get overwhelmed with the information available on the internet. The information that is found first or earliest need not necessarily be the most relevant one. Some guidance to give learners:

- Explore beyond the first set of results - Most learners tend to want to use the first source of information they find. Patience and determination are requirements for this learning method.
- Understand the different domains (.org, .com, .edu, .gov etc.) - The websites of non-governmental organizations generally have a URL ending in .org; while that of educational institutes ends in .edu. Commercial websites end in .com.
- Use a variety of search engines - Google is not the only search engine that can be used. There are many popular search engines like Bing, Yahoo etc. and there are scholarly search engines used by universities like Google Scholar, iSeek, Microsoft Academic, Wolfram Alpha. There are many more.
- Narrow down your search using keywords - in your searches you need to be more specific so that you can acquire accurate information.
- Crosscheck – just because something is on the internet does not mean it is true. Cross-check sources.

Preparing learners to use the internet effectively can make their and your life much easier. Giving a group of learners a topic to be researched using this learning method and giving feedback will enhance the understanding of this learning method.

Contribution to Systems Thinking competence

This learning method can help gather a range of information about various topics. It is essential that learners develop a critical understanding of information sources and the applicability of types of information to specific situations.

There is much information on the internet but without appropriate skills to review and use information, learners work can be confusing and not fact-based.

Learners should develop the faculty of assessing information and sources of information, not only with respect to the internet, but from other media sources as well.

Interview

Suitable for Steps 2 and 4, and possible to use in all the Steps

Duration

As per need

Material needed

Writing materials

Group size

Groups of three

Objectives

- Encourage learners to use their critical thinking skills.
- Give them chance to voice their own opinions.
- Encourage to question as well as generate answers.
- Enhance active listening skills.
- Promote communication skills.

Description

1. Assign a role to each learner: Interviewer, interviewee, note-taker.
2. Rotate roles after each interview.

   Have learners take turns sharing the information that they recorded when they were the note-taker

This is how the three-step interview process works:

Steps	Interviewer	Interviewee	Reporter/ Note taker
Step 1	Learner A	Learner B	Learner C
Step 2	Learner C	Learner A	Learner B
Step 3	Learner B	Learner C	Learner A

The three-step interview strategy is a collaborative learning technique that focuses on developing learners active listening skills; helps to develop their note-taking skills, and the ability to share information with others.

The method is mainly three question-and-answer sessions, where one learner is the interviewer, and another is the interviewee. The third learner is expected to listen actively and take notes during the interview. The strategy is designed as a fun, cooperative-learning method to help learners become more engaged and interested in their learning.

Here are some tips to keep in mind:

- Questioning – Teachers should provide a general topic or main question around which the learners can form their "Interview" questions. E.g., Cotton Jeans or Potato Chips.
- Interviewing – Before sending learners into groups for the interview, they must first know how to interview. Try role playing with learners beforehand or show them a video of an interview to familiarise them with the process.
- Timing – After the interview is conducted, learners need time to share. The best method for timing is to set an alarm and when it goes off (time over), the learners know they have completed their task.
- Recording – Consider giving learners a record sheet to write down their notes and interview questions.
- Sharing – Learners take turns to share information obtained in the interview.
- Naming – It is desirable to have learners name themselves as A, B, C. For the first round, all of the As will be the interviewer, the Bs will be the interviewee, and the Cs will be the note-takers/reporters. Once the first interview is completed, learners rotate and the As get to be the interviewee, and so on (as shown in the Table).
- Social Skills – Before asking the groups off to complete their task, first give them a few social skill tips, like what the appropriate noise level should be, how to have patience when waiting your turn, and how to be a good, active listener when they are the interviewer and the note-taker.

Contribution to Systems Thinking competence

Interviews are a method of collecting qualitative information that may give rich insights into particular topics. As such, collecting information from a variety of sources, using a variety of methods is more likely to give oneself a deeper, more well-rounded understanding about the chosen topic.

Mapping Technique: Concept Maps

Suitable for Steps 2, 3, 6 and 7

Duration

At least 30 minutes

Material needed

Freehand or mind-mapping software or simple drawing tools in word processing software.

https://www.xmind.net/

https://www.mindmup.com/

https://coggle.it/

Group size

Individual or in small groups of no more than three.

Objectives

To help learners visualize concepts, components, and their relationships, and represent them graphically.

Description

To prepare a concept map, learners list all the concepts and components related to their topic and arrange them in a hierarchical way with words. Ideas and information are represented with keywords placed in boxes or circles and connected with labelled arrows.

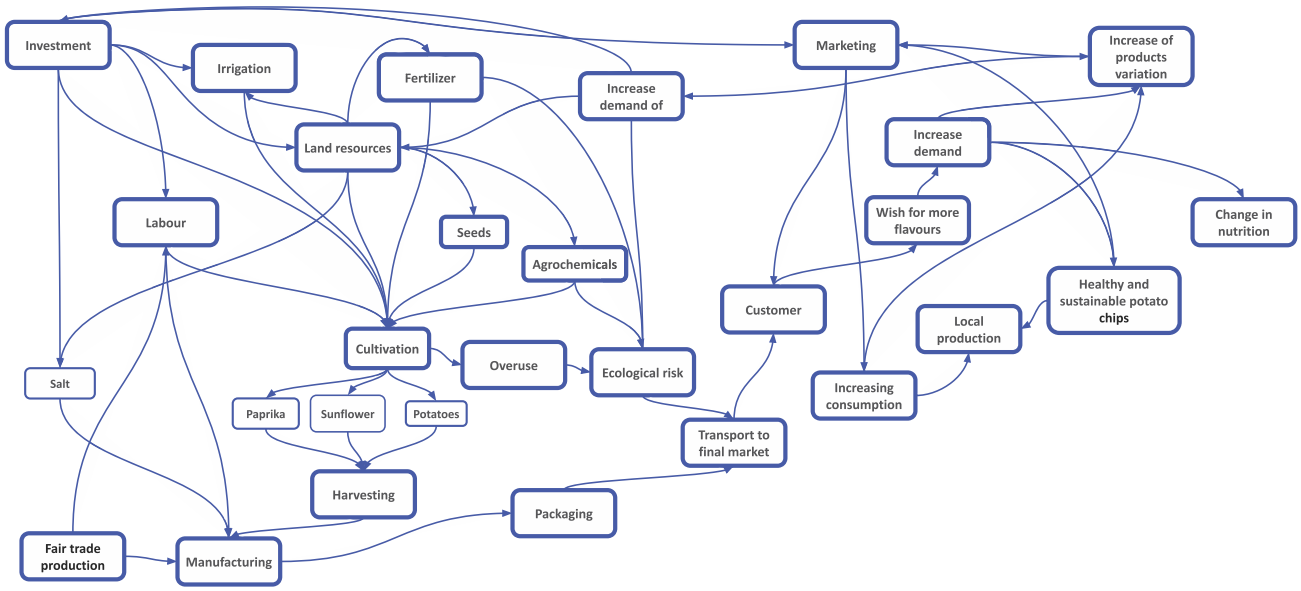
Characteristics of a concept map:

a. A hierarchical structure (from top to bottom)
b. Concepts are displayed in order of importance
c. Concepts are related by connecting words and directional arrows

Contribution to Systems Thinking competence

Concept maps are a way to develop logical thinking and identify connections and help learners understand how individual elements form a larger system.

Example



Mapping Technique: Mind Maps

Suitable for Step 2

Duration

At least 30 minutes

Material needed

Freehand or mind-mapping software or simple drawing tools in word processing software.

https://www.xmind.net/

https://www.mindmup.com/

https://coggle.it/

Group Size

Individual or pairs

Objective

To help learners organize information and present it graphically.

Description of task

Ask learners to collect information about the topic (such as by using interviews and internet search) and identify the main idea or question (say by brainstorming).

Guide learners to prepare mind maps as follows:

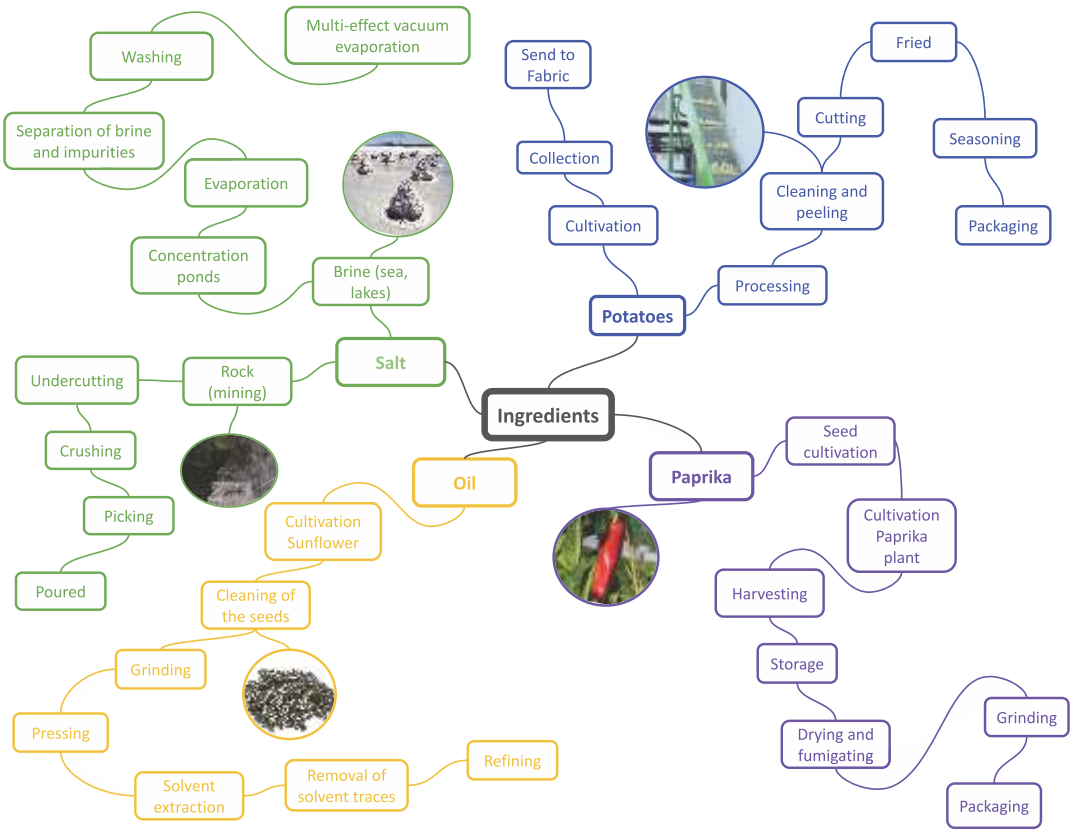
- The mind map structure goes from the centre to the periphery.
- Write the main idea in the middle of the sheet or blackboard.
- Add sub-topics around the main topic, creating branches, each in a different colour, if possible.
- Add more layers of elements and sub-topics in a tree-like structure radiating out from the central idea.

The structure can help learners identify interrelationships.

Contribution to Systems Thinking competence

The mind map is an expression of "Radiant Thinking" – associative thought processes that come from or are connected to a central point. Several directions of thought can be seen at one go.

Example
Chips mind map



Matrix of Influence

Suitable for Step 8

Duration

30 to 40 minutes

Material needed

Systems diagram

Group size

3-5

Objective

To identify the influence of one element (factors/ leverage points) over others.

Description

1. Ask learners to select important elements from their systems diagram which they feel have influence over other elements and try to identify leverage points. These elements are to be recorded in the matrix in the form of keywords. Each element corresponds to a letter in the matrix (see the diagram). The sequence or placement is not important.
2. To identify the influence of the element over others, the group always ask the same question:

   Is there a direct influence of factor A on factor B?

   If the answer is "No" enter a "0" in the corresponding field.
   If the answer is "Yes", go to the next question:
   Is this influence rather intense, medium, or weak?

   Enter 3, 2, or 1 in the corresponding field respectively (3 = intense; 2 = medium; 1 = weak).
3. Learners should proceed from the first row and work their way down, that is: Influence of A over B, A over C, A over D, and so on.

   For the analysis of the influence, we always start from the current state and not from a future situation, desired or imaginary. We always consider the factor in a "neutral" way without valuing.

   The question of "direct" influence is a matter left to the discretion of the learners. In many situations it does not generate differences of opinion and in other situations it does. This leads to a process of debate in search of more accurate assessment of the system model.
4. After completing the corresponding fields of the Influence Matrix, learners should add numbers in the vertical and horizontal lines, and they will obtain for each factor the following:
   1. The Active Sum (SA): This indicates the intensity of the factor´s influence on the global system in relation to the others.
   2. The Passive Sum (SP): Indicates the intensity (relative) that the other factors have over this factor.

Example of an influence matrix

Influence on / Influence of	A	B	C	D	E	F	ΣSA
A. Type of calories in a potato chips package	X	3	2	1	3	2	11
B. Health issues	3	X	3	2	3	2	13
C. Increase of consumption	3	3	X	3	3	3	15
D. Marketing	1	2	3	X	3	3	12
E. Increase in demand	1	2	3	2	X	3	11
F. Land resources	1	2	3	2	3	X	11
	9	12	14	10	15	13	X
SAxSP	99	156	210	120	165	143	

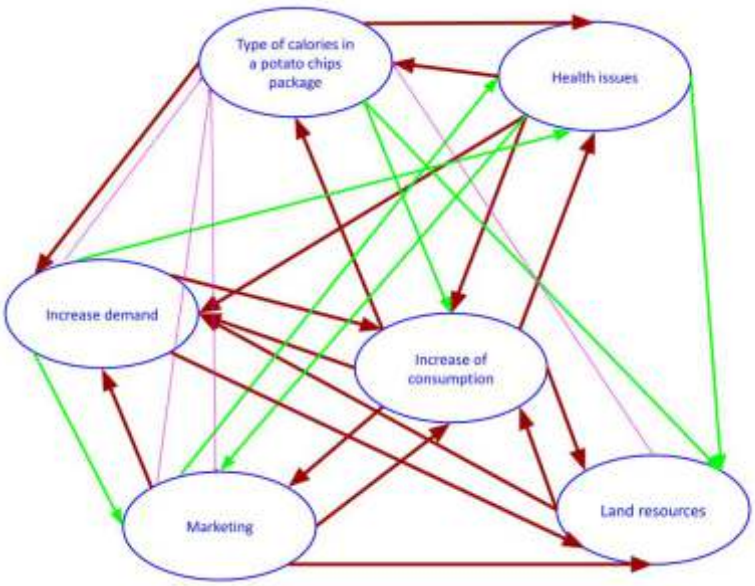
Once the matrix contains all the information, the learners may create a visualization of the data to represent the influences among elements.

Each group must select the factor that shows the highest result of SA and SP. The element that has the greatest number of incoming and outgoing connections should be in the centre of the drawing.

Next, starting from this factor, integrate all the streams of effect with intensity "3" (using thick arrows or specific colour) in the visualization. Then, they have to register the factors with medium and weak effects with arrows of a proportionate thickness (or in other colours). The objective is to maintain the overview in all its complexity.

The Effects Structure is a representation that shows us the direction and intensity of how an element influence other elements.

With the help of the Effects Structure, it is possible to clarify how the system works. Starting from a certain factor, we can follow the diffusion of its effect on the system.



Moving Game

Suitable for Steps 3, 4 and 7

Duration

15 minutes

Material needed

Open space

For the variation name cards and safety pins, equal to the number of learners.

Group size

Up to 30

Objective

To help learners understand that connections between elements in a system result in dynamic behaviour of the system, and that these connections may not always be visible or easy to discern.

Description

Complex realities are difficult to understand because learners need the ability for abstract thinking, which often may not (yet) have developed. Translating real processes into body movements can help learners bridge the gap between their individual abstract thinking and complex reality.

Elements in a system may have more than one type of change through space and time. You may explain multiple complex changes in the situation of an element using the example of a tornado. A tornado has a moving speed as well as a turning speed. By moving from one side of a room to the other side and simultaneously turning oneself around at a much faster speed, helps to understand the dynamics of a tornado.

Moving Game

1. Take the learners to an open space or a spacious room. Ask them to form a circle.
2. The first rule of the game is that nobody should tell anything or pass any signal to anyone until the game is over.
3. Now, everyone has to mentally select any two persons in the circle as partners but not disclose who these partners are.
4. Next, they all should move from their places and locate themselves permanently at such a place from where the distance to both of their partners is the same. They should continue to keep an equal distance from the chosen partners until the trainer/ facilitator tells them to stop.
5. The facilitator/teacher should stop the game after two to three rounds.
6. Ask the participants to share what they observed. Centre the discussion on the theme of 'interdependence'.

Ask the participants to share what they observed. Centre the discussion on the theme of 'interdependence'.

Variation - Moving Game with 'element cards'

1. Print the card template below, or prepare cards, each with one different element in the model written on the front side of the card. Then, on the back of the card, write the elements related to it.
2. Distribute the cards among the learners. They see the element they would represent on the front of the card. The element they are related to is mentioned on the back of the card. You may use Worksheet in the next pages.
3. The rule is not to comment on which other elements they are related to. Note: The number of cards can be more or less, depending on the size of the group. If needed, elements can be repeated on the cards.
4. Participants should form a circle. At a signal, they should move, keeping an equal distance from the partner elements (they should not reveal the names of the partner elements). The participants should pin the card to their shirt or hold it up so that the front side is visible to the other participants.
5. Once the group is in movement for a few minutes, select one element and ask the participant to kneel and wait to see the reaction of this action.
6. Discuss with the group:
   - The model is the representation of a dynamic system, where the elements are interrelated. When the dynamics of one or more elements changes or stops altogether, it affects the other elements in turn. Thus, the primary learning point for learners in this activity is to understand that the elements in the system to produce a pair of jeans are interrelated.
   - Discuss what the purpose of the Jeans system is (e.g. earn a livelihood for farmers, profits for the jeans company, clothes for people etc.).

Contribution to Systems Thinking competence

Learning by moving helps learners understand the dynamics within a system better.

Cards for the Moving Game of Cotton Jeans

(The next few pages)

Print and cut each of the blocks to prepare the cards. The front of each card names an element, while the back of the card is an element it is related to. The participants should fold the card and pin it to their shirt so that the information on the back is not visible to others.

Front	Back
Element **Cotton seeds**	Related element Land resources
Element **Irrigation system**	Related element Land resources
Element **Investment**	Related element Land resources
Element **Investment**	Related element Irrigation system
Element **Investment**	Related element Cotton
Element **Land resources**	Related element Cotton
Element **Cotton**	Related element Harvest
Element **Harvest**	Related element Production of yarn
Element **Dyeing**	Related element Production of jeans
Element **Cutting**	Related element Production of jeans
Element **Sewing**	Related element Production of jeans

Front	Back
Element Yarn Production	Related element Dying
Element Yarn Production	Related element Cutting
Element Yarn Production	Related element Sewing
Element Production of jeans	Related element Transport to the final market
Element Transport to the final market	Related element Jeans shops
Element Jean shops	Related element Customer
Element Designing	Related element Global fashion
Element Designing	Related element Cutting
Element Increase demand	Related element GMO cotton
Element Increase demand	Related element HYV of cotton

Front	Back
Element GMO Cotton	Related element Higher cotton production
Element Increasing world population	Related element Increasing demand
Element Higher cotton production	Related element Increasing investment
Element Higher cotton production	Related element Increasing land prices
Element Increasing investment	Related element Investment
Element GMO Cotton	Related element Ecological risks
Element Increasing land prices	Related element Competition between cotton and food production

Narration and Storytelling

Suitable for Step 8, 9

Duration
30- 40 minutes

Material needed
Positive narratives or stories

Group size
Up to 30 or larger groups

Objective

To engage learners in positive, solution-oriented learning and action for sustainable development.

Description

Our globalized world has many challenges - from poverty to climate change, and loss of biodiversity. With the "2030 Agenda", the United Nations has set a global development program to face these challenges. Education for Sustainable Development (ESD) offers the possibility to address these challenges as opportunities to develop better solutions. The learning method of storytelling or using narrations is well-suited for this.

When introducing or discussing global challenges, teachers can narrate real life cases about people with new ideas, actions related to the selected topic, and their success stories or experiences.

Of course, the lessons may not be limited to the stories and in no case ignore the real challenges and their various dimensions. Instead, the stories may be used to reflect on their transferability to other contexts or to inspire creative solutions for other challenges.

To tell an engaging story, try to structure your content:

- Setting - characters, place, time
- Problem starting event
- Character - reaction and plan
- Attempt(s) to solve problem
- Consequences
- Resolution

Contribution to Systems Thinking competence

Systems thinking in the context of ESD can be exploratory and solution oriented. The use of positive stories encourages solution-oriented attitudes and can inspire creativity in the search for further solutions, as compared to a problem-oriented approach.

Examples

Stories about low fat potato chips, collaborative production systems, organically grown cotton or other sustainability ideas, products and strategies might be suitable in this context.

Teaching the Sustainable Development Goals

This resource provides information about the SDGs and offers suggestions on how to teach and support learning for sustainable development. Each SDG-chapter in this book opens with a note on the nature of the challenge. Many of the challenges are not new to us and there have been efforts to alleviate them. Seventeen such relevant and meaningful efforts are offered in this resource as "stories of change" to illustrate how every effort matters and that there is something tolearn from it. These stories have been taken from the four ESD Expert Net member countries: Germany, India, Mexico, and South Africa. You can download this resource from the ESD Expertnet website.

https://esd-expert.net/files/ESD-Expert/pdf/Teaching_the_Sustainable_Development_Goals.pdf

Additional resources

Storytelling

https://www.education.vic.gov.au/childhood/professionals/learning/ecliteracy/interactingwithothers/Pages/storytelling.aspx

National Geographic Education Blog | Strategy Share: *The Power of Storytelling for Conservation*

https://blog.education.nationalgeographic.org/2018/10/08/strategy-share-the-power-of-storytelling-for-conservation/

Outsider

Suitable for Step 1, 2, 3

Duration
30 minutes

Material needed
Sheets of paper or blackboard and chalk

Group size
Pairs, up to 30

Objectives
To enhance the learners' reasoning ability and the ability to present logical arguments.

Description
Arrange lines of three or four words connected to the chosen topic, such as cotton or potato.

For example:

potato	tomato	soil	hoe
jeans	shirt	yarn	indigo

The learners have to exclude one word per line and justify their decision.

As you try it yourself, you will quickly recognize that a case can be made to remove any of the items.
For example,

- One can eliminate "indigo" since it is the only item not made of cotton
- One can eliminate "jeans" saying one might produce a shirt dyed with indigo

The idea is to train the mind to think in a divergent way and develop and articulate arguments. The game also shows that there is not only one correct answer, and that different possibilities are open for discussion.

Contribution to Systems Thinking competence
This learning method helps to train the mind to think in a divergent way and develop and articulate arguments. The game also shows that there is not only one correct answer, and that different possibilities are open for discussion.

Divergent thinking, being open to new possibilities, and be on the lookout to discern connections between different elements aids systems thinking.

Panel Discussion

Suitable for Step 6

Duration
Up to 1 hour

Material needed
Table, chair, name tags, microphone (if required)

Group Size
10 to more than 200 persons

Objectives
To encourage learners to develop their thinking on different dimensions of a topic and articulate it as part of a discussion.

Description

In a panel discussion, a group of three to five learners, appointed as panellists, examines, and discusses a problem or topic to reach a compromise or consolidation of different opinions and perspectives about the topic.

The panel members conduct their discussion in front of the whole group. The panel discussion has a moderator who introduces the topic. In the first round, the moderator invites each panel member to first present his/her views. In the second round, he/she invites each member to discuss or comment on the views presented in the first round. At the end, the moderator summarizes the different key aspects of the topic.

Before the panel discussion, engage the whole group in a preliminary discussion about the topic.

1. Introduce a problem on which different and conflicting opinions exist or are possible.
2. Have learners work in groups to enumerate as many aspects and different opinions on the topic as possible.
3. Each group sends a member into the panel discussion group. One of them is chosen to be the moderator.

Notes:

1. The central problem must be clear to the panel members.
2. One of the panel members must be a moderator who seeks views or opinions from panellists.
3. Select panellists appropriately, based on the problem to be discussed.

4. Panellists must be thoroughly briefed as regards their roles and possible opinions.
5. If you follow the strict procedure of a debate, the consensus reached by panellists must be respected, while in a discussion or learning situation it may remain open.
6. The teacher should ensure that the audience or rest of the learners are aware of the main conclusion at the end.

Contribution to Systems Thinking competence
As the groups are looking at one problem from different perspectives (different roles and interests) all members learn to identify conflicting interests and learn how to look for solutions and reach a consensus on the topic addressed.

Podcast

Suitable for Steps 4, 5, 6, 7, 8 and 10

Duration
One to several hours

Material needed
Access to internet, recording technology

Group size
Groups of not more than four

Objectives
To help learners explore a topic through group discussions, prepare a structured text or script, record it as an audio programme, and present it to others via suitable equipment or digital platforms.

Description k
Introduce the topic to the class and ask learners to prepare podcasts. A podcast is essentially a talk or interview in audio format.
For this:

1. Divide the class into four and allocate topic or sub-topics
2. Explain that each group has to search for information, discuss among themselves for how to structure the information, prepare a script and finally record the speech or audio in a suitable style.
3. The digitally produced podcast may be uploaded to the internet or shared among a closed learning group.

Contribution to Systems Thinking competence
Learners are trained for individual and group work to prepare and share structured explanations of complex topics.

Example
Many subtopics of either cotton jeans or potato chips, their production, advertisement, supply, or global trade can be chosen as the topics for podcasts.

Role Play

Suitable for Steps 2, 6, 10

Duration
Minimum of one hour, up to one day

Material needed
Topic related information material for the various roles

Group size
6 – 8 learners may play the given roles, while a group of 30 to 50 may observe and contribute to the reflections on the learning from the role play.

Objectives

- To help learners get insights into the reality of different individuals connected to the study subject, by simulating a situation relevant to the topic, and having learners play the roles of such individuals.
- To help learners put themselves into the shoes of people connected to their subject of study.

Description
A situation relevant to the group (such as of a conflict, if applicable) is presented. Learners assume roles and have a discussion to address the problem posed.

This method should be used above all when it is a question of promoting aspects of action and adopting lifelike observer positions.

Role plays may be conducted in four phases:

(1) **Warm-up phase**

The warm-up phase (before longer role plays) serves to loosen up and relax all participants at the beginning of each lesson/ session. In this way, they are prepared to put themselves in other roles.

(2) Acting phase

The acting phase is divided into development and implementation.
In the development phase, a relevant topic (content, conflict) is discussed together with the group. There upon a situation is determined for the execution of the role play and the different roles are worked out. Apart from the actors it is important to have a group of observers and to assign them with different tasks (also refer to the extension of the method).

(3) Dismissal phase

In the dismissal phase, the players are led out of their roles in order to be able to adopt an "outsiders" view. Only through distance can the game be analysed. The separation of role and person is important so that the conflicts that arise in the role play are not transferred to everyday reality. The phase also serves to protect the players, because criticism of the role behaviour must not become criticism of the person.

(4) Reflection phase

In this phase, the retrospective learning process takes place through reflection, discussion, raising comments, alternative solutions, etc.

Related to the player:
Report of the players about their sensations during the role play.

Related to the observers:
Observation skills are to be developed (possibly through observation tasks).

Related to the role play:

Clarify the action by:
- correcting misunderstandings and mistakes
- working out preconditions and changes that occurred in the course of the game
- analysing causes for the action
- helping to draw conclusions from the behaviour
- relating actual events to intended goals
- reinforcing and correcting learning outcomes

Contribution to Systems Thinking competence

In Step 2, a role play can help learners better understand a situation and aid in the development of a model of the system.

In Step 6, it can be a supporting method to understand more deeply situations of dilemma or conflicts between SDGs (say, SDGs 8 and 13). At the same time, it can help to reflect in Step 10 on different aspects of actions, which constantly need revision and adaptations.

See examples of role plays at https://fairtrade.wales/wp-content/uploads/Lessons-Cotton-and-Fair-Trade-for-Secondary-Schools1.pdf

Variation: Analytic or Reflective Teams
If the group size allows, observers can be formed into different groups, to have a bigger spectrum of views during the reflection phase.

Objective

To gain more knowledge through group reporting and learn that a topic can be viewed from different perspectives.

Description

1. Introduce a topic for the role play (see above)
2. Form groups of four or five observer groups, assigning each team with different tasks, for example:

   Group 1: Summarizers
   Task: prepare a summary of the task (in not more than 7 most important points).

   Group 2: Questioners
   Task: prepare three substantive questions on the topic or task.

   Group 3: Proponents
   Task: list three to five arguments in favour of the most important points of the role play

   Group 4: Critics
   Task: list three or less points on why they disagree with key opinions expressed in the role play.

Contribution to Systems Thinking competence

The method helps develop insights into the different situations that people face. Considering that one of the aims of the Systems Thinking is to address problems, gaining such insights contribute towards working out better solutions. Role Play can help support analysis and reflection on the topic chosen for systems exploration.

Scenario Analysis

Suitable for Steps 5, 9

Duration
1 to 2 hours

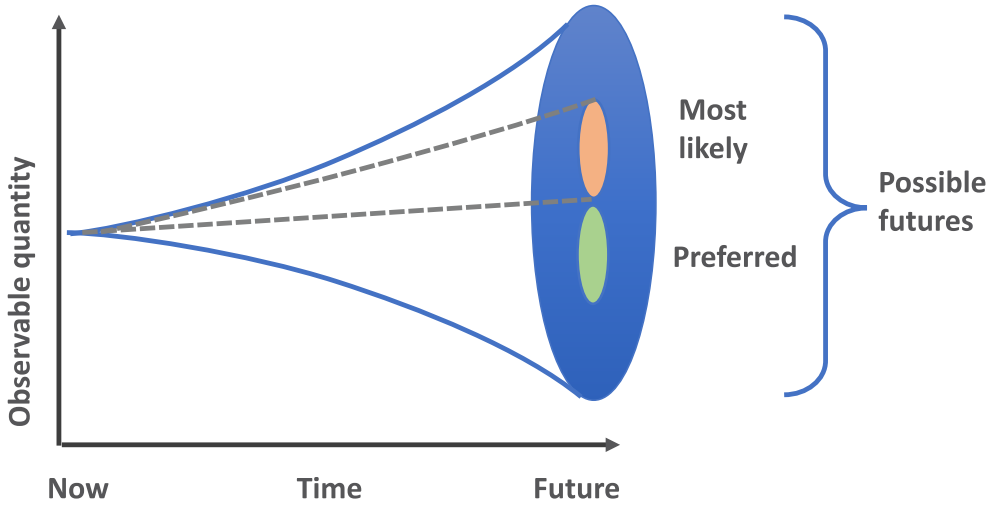
Material needed
Paper, pen, internet access, printer

Group size
Up to four

Objective
To help learners envision the future of a chosen topic or process.

Description

1. After the learners have defined their topic, they should choose a specific point of time in the future around which they will concentrate their analysis. For example, five, ten or twenty years into the future. The farther the point of time in the future, the broader the analysis will be.
2. After learners define this point, they should collect all available data concerning the past development of the chosen topic or process as well as estimations concerning its future.
3. In the case of cotton production, learners may collect data on the expected growth of the world population, expected purchasing power, and fashion trends for the defined year.
4. Knowing the past trends, and a business-as-usual scenario, learners can extend the graph for the behaviour of selected parameters in their diagram (see examplebelow) for the defined year in the future. Learners should plot the collected data on a graph for a best and a worst-case scenario.
5. A funnel-shaped graph would result, depicting the possible futures in the selected time frame, including in a business as usual (BAU) scenario, and the best- and worst-case scenarios considering current knowledge.
6. The scenario analysis can help simultaneously to decide which future we want to have and understand the conditions necessary to reach that.



Example
The IPCC Sixth Assessment Report presents the scenarios of future additional warming with 5 trends of future emissions.

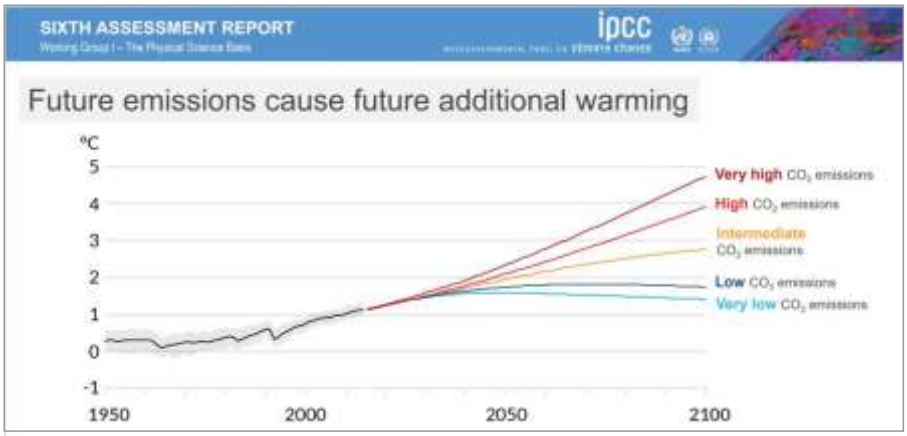


Figure 10 Scenarios of global warming with future emissions, presented in IPCC AR 6
https://www.ipcc.ch/report/ar6/wg1/downloads/outreach/IPCC_AR6_WGI_Press_Conference_Slides.pdf

Contribution to Systems Thinking competence
Learners can get an idea of the future society, within a time frame of five to ten or even fifteen years, using documented evidence, current behaviour of the system, and by making realistic assumptions of the future development.

Learners understand how to predict the behaviour of systems.

SDG Analysis Matrix

Suitable for Steps 6, 9, 10

Duration
30 to 60 minutes

Material needed
Copies of SDG analysis matrix, one for each learner

Group size
Pairs

Objective
To help learners analyse a topic using the "2030 Agenda" as a framework and identify opposing interests or dilemmas.

Description

1. Ask the learners to analyse the system/model they are working with, using the Sustainable Development Goals (SDG) as a framework.
2. They have to assess for every single SDG, whether the system behaves in a way aligned with the aims of the SDGs. You may select certain parameters of interest to be assessed, according to the dimensions you think would be useful to highlight, and the level of complexity the learners may be able to handle.
3. Learners should note any possible contradictions between the outputs or behaviour of certain elements of the analysed system and the SDGs.

Contribution to Systems Thinking competence
The task contributes in a very specific way to systems thinking, since it takes contradictions as characteristics of systems into consideration and enlarges the learners' understanding about systems.

Systems have inputs and outputs, composed of materials, energy, and information, which may also be viewed as purposes and impacts. These may deplete or enhance human well-being as well as environmental quality. The activity encourages learners to think about the purpose and impacts of systems and assess whether they contribute to the SDGs.

Example
Eco-friendly production of cotton is desirable as a contribution to conserving terrestrial biodiversity. (Goal of SDG 15) However, as the production rate of natural eco-friendly cotton might be lower than Genetically Modified (GM) Cotton production for the same acreage of cropland, such a production system may contradict SDG 8 which aims for economic growth.

SDG Analysis Matrix

.....

(Title of the System Analysed)

SDG	Elements from your system model that contribute to the SDG	Elements from your system model that are counter-productive to the SDG	Elements from your system model that contribute to one or more SDGs, but pose a problem for other SDGs
			
			
			
			
			
			
			
			
			
			
			
			

Station Learning

Suitable for Steps 2 and 3

Duration
From 2 to 10 hours

Material needed
Tables, learning diary

Group Size
Up to 30

Objectives
To help learners analyse a topic from different perspectives and comprehend how the different aspects are interlinked.

Description

This method helps learners to deal with complex topics, by exploring each aspect in detail in small groups. When they have completed all stations, the learners will have a much deeper understanding of the complexity of the topic.

The teacher has to offer a variety of tasks on different aspects of the topic for learners to develop their own learning path. Each student can decide how many stations to work on.

The teacher sets up fixed Learning Stations within the classroom, where a particular task can be found. At each Learning Station a minimum of one task is given. Further tasks on the same topic for in-depth learning can be offered. A certain timefra me is defined for the time spent at each station.

Each station is designed in a way that it addresses a certain aspect of a topic, which reflects only one aspect of a systems approach. Much time therefore goes into proper planning.

Some learners can decide to become experts in a chosen station and help the teacher in facilitating. Certain learning tasks/ stations can be defined as mandatory (minimum requirements).

You can use the notes from all the stations as a learning journal. The collection of the portfolio of results is helpful to review the learning.

Procedure

1. Planning and Conception: Choose the topic, and sub-topics. Define learning objectives and sub-goals. Check if a specific grouping of content necessary, or a sequence of learning.
2. Practical preparation and provision of Learning Stations:

   Think about the physical materials needed

   Develop the tasks – write the instructions of the task, craft instructions, experimental set-up etc.

   Prepare a checklist, design a support system if needed (such as “experts”, reference materials).

   Set-up the physical workstations (signage), layout of workspaces.
3. Introduction: Explain the idea, workstations, time frame, working regulations (group work etc.), learning objectives, requirements, time for a getting to know the workstations (overview, familiarisation).
4. Implementation: Provide the time – 2 to 10hours; support the learners to take up their individual or group work at each station; having explained all

the tasks, the teacher should be available for support but allow the learners the time and space to get into their tasks and intervene rarely.

5. Learning assessment and presentation: at each station each student/groups writes the results of a task in the learning diary; each individual group presents what they have learnt at each station to the entire class.
6. Reflection of the learning process with the learners.

Contribution to Systems Thinking competence
Learners learn how to deal with complex issues and reflect on the learning process. They will realise that the group might have come to the same results and also appreciate that it is helpful to work in teams, since each team adds to the learning process by bringing in new aspects.

Structured Description

Suitable for Steps 1, 3, 4, 6 and 10

Duration
Up to 30 minutes

Material needed
Writing materials

Group size
Pairs (preferred) or individual

Objective
To strengthen the ability to describe a given situation or item or medium (print, video, image, label), in a detailed and structured manner.

Description

With the detailed description of an everyday item like a packet of chips or a pair of jeans, learners will strengthen their specific competence. They will also extend their knowledge – for example, about ingredients or material – and achieve insights, which may lead to further questions.

Learners may start their structured description by first mentioning the source or author of the information, its medium, and the topic, situation, place, and year of publishing. In the second step, the main elements of the information should be described.

To avoid associative descriptions, learners should separate the fore-, middle- and background information, such as in the different parts of a picture. For example: standing in the playground of a school, you may see children engaged in play, with the school building behind them, and in the background, you see a hilly landscape.

Contribution to Systems Thinking competence
A structured and detailed description presents the perception of the learner about a given situation or material. In this sense, a well-done description will be the base of the subsequent differentiated analysis and assessment.

Example
A first verbal example, done jointly with the whole group could be simply "look out of the window of the classroom and describe what you see". Later, you can ask the learners to describe the first central item by which they begin their systems work, such as a pair of jeans or a packet of potato chips.

Extension/variation
See Back-to-Back Sitting or Telephone Call as supporting methods for training learners to develop structured descriptions.

Taboo!

Suitable for Step 1, 4

Duration
10 to 60 minutes

Material needed
Prepared cards

Group size
Up to six

Objective
To strengthen the learners' reasoning ability, expression, and vocabulary.

Term - a word or phrase used to describe a thing or to express a concept, especially in a particular kind of language or branch of study.

Description

The basic idea is that learners have to explain a term without using a number of words. Learners get a card with the term to be explained, as well as certain words they are not allowed to use to explain the term.

Contribution to Systems Thinking competence

The explanation of a term without key words is possible if one understands the term. Taboo is a way of encouraging learners to think about terms and try to comprehend the meaning in a deeper way. Learners draw upon your vocabulary and ability to describe by using other words and in the process, delve into more complex thoughts.

Examples
Explain "chips" without using the words "potato", "snack", "crisp" or "crunchy" or any brand names.

A possible answer could be"a food item, enjoyed by people of all ages, made from tubers, available in colourful packets".

Explain "cotton" without using the words "plant", "wool" and "white"

A possible answer could be:
The word I have to explain marks an agricultural product, which is mainly produced in semi-arid regions like South or Central Asia, where sufficient high temperatures are provided as well as the possibility to irrigate. The part of that agricultural product, which is of economic interest, is its fluffy part surrounded by carpels. This soft stuff is processed and is used to produce yarn, cloth and billions of T-Shirts, underwear, and skirts for the global market.

Telephone Call

Suitable for Step 1

Duration
30 to 40 minutes

Material needed
Mime or 'pretend phones' (empty match boxes or toothpaste packages), or even real cell phones.
Group size
Pairs

Objective
To strengthen the learners' ability to describe a given situation or topic in a detailed, structured and clear manner.

Description

1. The learners sit in pairs.
2. They simulate a phone call in which one member of the pair describes a given situation or picture to his or partner on the phone (make-believe phone).
3. The listener is allowed and encouraged to ask questions to clarify the given description.

Contribution to Systems Thinking competence

The method helps learners to focus their thinking on a particular object or situation. Learners can prepare first descriptions of their understanding. They can continue to enrich the description through other methods such as internet research and interviews. Such a description forms the basis for further analysis.

Example

"Describe the flowering of a cotton plant" or "describe the processing of cotton to yarn" are suitable topics for such phone conversations. Similarly, "describe the steps of chips production" is another suitable task.

Think, Pair, Share

Suitable for Steps 1, 2, 3, 4, 6, 10

Duration
15 to 90 minutes

Material needed
Writing materials

Group size
Pairs, overall group of 30

Objective
To strengthen learners' individual ability to communicate and cooperate in mutual learning.

Description

1. Think, Pair, Share is a collaborative learning method, in which individual learners take up a task, then share their thinking with their partner in a pair to develop it further, and then share their joint thinking with the larger group.
2. For example, if the task for the learners is "Describe your surrounding reality!", each

learner has to reflect (Think) on his/her own, say for five to ten minutes and jot down their thoughts

3. They should turn to their partner and present their notes (Pair).
4. Each pair should review their individual description or agree on a common text.
5. Next, each pair presents their notes to the whole group (Share).
6. The teacher can then help to summarize and lead to an improved collaborative final description.

Contribution to Systems Thinking competence

Learners experience how cooperation works and how single elements, insights, facts, or argumentsfit into a larger context.

This general experience may be enhanced by choosing topics that lend themselves to a higher complexity.

Transfer

Suitable for Step 8

Duration
Depends on the task and the complexity of the topic.

Material needed
Information on case studies.

Group Size
Individual, in pairs, or as a group

Objective

To enable learners to transfer knowledge, facts and/or insights gained while working on a topic, to another similar, but unknown topic.

Description

Present an example that illustrates the topic chosen suitable to represent its general characteristics. For example, if you teach about deserts, you might choose the Sahara as a representative example. The facts, knowledge and insights the learners gain by dealing with deserts in general and the Sahara desert in particular enable them to transfer that learning to other deserts like the Thar, Kalahari or Mojave Desert.

Contribution to Systems Thinking competence

The ability to transfer knowledge and insights from one topic to another and apply the developed competences. It will also have benefits in the context of systemic thinking.

Example

Understanding the principles of interventions in systems, enable the learners to transfer their knowledge to identify potential interventions in systems of their choice. If they enhance their ability learning about cotton, they might be able to transfer their experience and developed competence on the topic "potato chips".

Understanding Causation

Suitable for Steps 3, 4 and 5

Duration
90 minutes

Material needed
Writing materials

Group size
Up to 30

Objective
To help learners understand causal relationships between elements of a system.

Description
To help learners understand causal relationships between elements, you may engage them in a few simple group activities and explain as you go along.

Cause and effect (Causal) links
We know that elements in a system are interconnected. These interconnections may be of different types. One type of interconnection is a cause-and-effect relationship. That is, a change in state of one element may cause one or more elements connected to it to change.

Conduct these activities with the learners:

Exercise 1

Ask learners to carry out these simple exercises:

- Bend both your hands and keep them in a position, parallel to ground.
- Now let us consider that the movement of your

right hand will affect the movement of your left hand. The, left hand will move only if the right hand moves. And if right hand remains stationary, then the left hand will also remain stationary.

- The movement of the left hand is an effect, and the movement of the right hand is the cause of that effect.
- This type of relation is called 'causation' because a change in state of the right hand (cause) is causing the state of left hand to change (effect).

Exercise 2

- Read the following cause and effect relationships
- Write why you agree or do not agree with each of these relationships
- Your friends might have different answers; share your work with them

Water quality	→	Biodiversity in a pond
Food shortage	→	Food availability
Hunger	→	Chips eaten
Advertising	→	Jeans sold
Advertising	→	Chips sold

Explain to the learners:

1. It is because of such cause-and-effect connections that an intervention intended to change the state of some system element (implementation of malaria eradication program) can eventually alter many other system elements (such as mosquito population, migratory human and livestock populations, stock of minerals and forests cover and vegetation type etc.).
2. Here are examples of such relationships, indicated by drawing an arrow between the two.

   Amount of food intake→Body Weight

   Number of saplings planted→Number of trees
3. Two elements, between whom a cause-effect relationship (called hereafter causal connection) exists are represented at the ends of an arrow. The element at the arrowhead is the 'effect', whereas the element represented at the tail of the arrow is the "cause". The arrow between the two phrases can be read as "affects", "influences" or "causes". The meaning of all these words is almost the same. We use the word "causes" in this activity.
4. Thus, the causal links shown in point 2 above can be read as "amount of food intake causes the body weight to change", and "the number of saplings planted causes number of trees to change."
5. When studying a situation from a systems perspective by using the Cause-Effect tool, the focus is to look for and capture the "cause-effect" (or causal) relationships between system elements. Some elements may not be connected in cause effect relationships, while others are.
6. In some cases, it may appear that elements have a cause-and-effect relationship, but further investigations may reveal that there is no real cause effect relationship. On the other hand, no cause-effect may be visible, but further investigations may reveal that such a relationship is in fact present.

   Note that correlation does not necessarily mean causation.

   A **correlation** exists between two variables, when one variable changes, the other variable also changes.
   Causation is when a change in one variable causesa change in the other variable.

7. In the world, we find that most elements are connected with several other elements and it is possible that each one of them could be affected by several others.

   While drawing causal links between two elements, the influence of all the other elements must not be mixed up together. For instance, one can say that the state of forest resources changed because of government policies.

   This is not untrue; however, aggregating several influences together could give us only a limited understanding and short insight to intervene in the system. Therefore, each one of the influences should be considered independently. (See Figure 1)

Figure 1

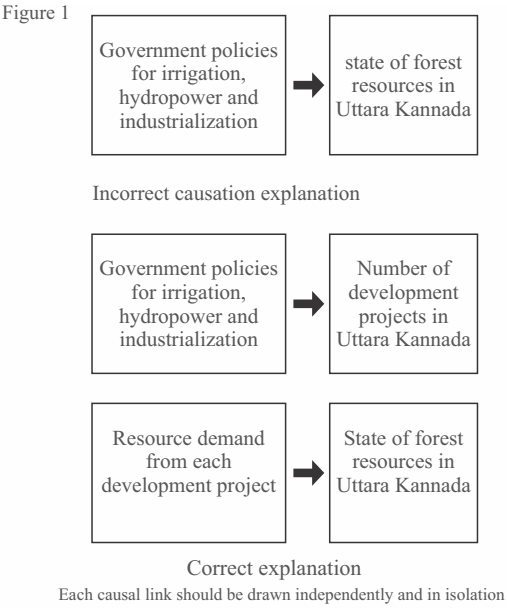
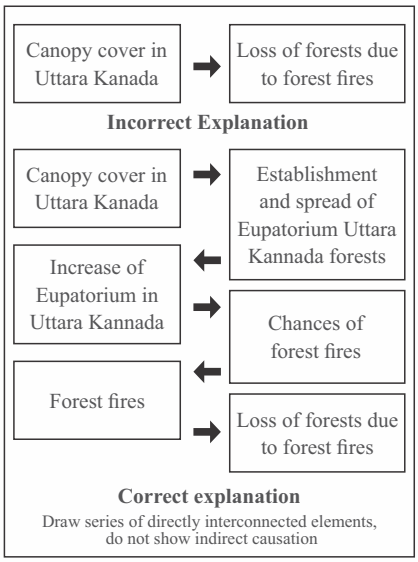


Figure 2



Also, only direct influences must be considered. For instance, because greater number of learners were willing to plant saplings, greater number of saplings were planted and thus it caused number of trees to change. While describing this, one may get tempted to establish a link between number of learners willing to plant sapling and number of trees. This must be avoided. Instead, a series of influences can be drawn, by considering each relationship independently and in isolation.

See a similar example shown in Figure 2. The correct mutual interplay of all influences is found later as we go on developing the diagram. The loss of canopy cover in the forests of Uttara Kannada district in India caused the spread of the invasive plant species Eupatorium, which led to an increase in the risk of forest fires.

Positive and negative causation

When we say an element causes another to change its original state, the change can occur in two possible ways.

Positive Causation is when the state of the second element increases due to an increase in the first element and decreases with a decrease in the state of the first element. This means that the second element changes in the same way as the former changes. We use '+' sign placed above arrowhead to indicate this type of change.

Negative Causation is when the second element (i.e., effect) changes in the opposite manner. That is, if an increase in the state of the first element causes a decrease in the state of the second element and a decrease in the state of the first element causes an increase in the state of the second element. We use '-' sign placed above arrowhead to indicate this type of change.

The activity below would help illustrate the concept.

Activity

Draw a plus sign on a paper and pin the paper on your chest. What is the meaning of this sign? This means that your left hand will move towards the same direction where your right hand moves. This means that if you moved your right hand in the upward direction, then your left hand will also go in the upward direction. If the right hand comes down, the left hand will also do the same. This type of relation is called 'positive causation'. The left-hand acts as per the actions of right hand.

Now pin a minus sign on your chest. Your left hand will move in the opposite direction of the right hand. If you move your right hand up, then the left will go down! And if the right moves down, then the left will move up. This type of causation is called 'negative causation'.

Draw the learners' attention to the fact that though we use the words positive and negative, it does not mean that positive is correct and negative is wrong. We are using plus and minus signs only to show whether the second element (left hand) changes in the same way that the first (right hand) does or in the opposite manner.

Read out the following causal connections to the learners one by one and write them on the

blackboard. Ask the learners whether the causation is positive or negative.
Mark a '+' sign at the top of arrowheads if the learners think they are positive causations and a '–' sign if they think they are negative causations

Chances of death due to malaria	→	Deaths due to malaria
Wood processed by paper mill	→	Paper produced
Lands submerged under reservoirs	→	Lands available for agriculture
Births	→	Population
Deaths	→	Population
Livelihoods	→	Pressure to mitigate
Food availability	→	Food shortage
Resources available	→	Concern about conserving resources
Carbon emissions	→	Global Warming

Contribution to Systems Thinking competence

Understanding cause and effect relationships and learning how to present them is the foundation of the Systems Thinking approach. We can recognize that events, situations, or problems are not stand alone, that occur on their own without a reason. Rather, they are part of a complex chain of events and cause and effect relationships. Training the mind to understand cause and effect is about seeing beyond what may appear to be isolated events, to identify patterns and connections. It helps the learners understand systems and prepare systems models to share their thinking with others.

Video Content Analysis

Suitable for Steps 2, 3, 6, 7

(Or whenever video content analysis is needed)

Duration

1-2 hours

Material needed

Video player, tablet or desktop computer, internet
Writing materials

Group size

3-4

Objectives

To enable learners to examine videos (or texts, audio materials) related to a topic, to discern patterns, and to describe the patterns in their own words.

The analysis qualitative (focusing on understanding and interpreting) and/or quantitative (focusing on counting and measuring) in nature.

One can apply content analysis to a broad range of texts, audio, visual, and performative materials. it is used in a variety of fields, including marketing, media studies, anthropology, cognitive science, psychology, and many social science disciplines.

Content analysis has various possible goals:

- Finding correlations and patterns in how concepts are communicated
- Understanding the intentions of an individual, group or institution
- Identifying propaganda and biases in communication
- Revealing differences in communication in different contexts
- Analysing the consequences of communication content, such as the flow of information or audience responses.

Description

1. Once learners have defined their topic and formulated clear research questions, you could start them off by identifying suitable videos on the internet or other sources.
2. After screening the videos, learners may choose three to four videos, which seem to be the most promising ones for content analysis (choosing a sample).
3. Depending on the task, help the learners decide which type of analysis they may want to apply. For example: if learners would want to find out about future developments in potato production, they may want to write down all the relevant figures that give information on the past, present, or future production quantities (quantity of potatoes sliced, number of countries to import potatoes from, amount of salt used, number of flavours or artificial ingredients). In case learners would want to understand in detail how potato chips are produced, they may choose a more descriptive type of analysis, which highlights the different steps of production.
4. Encourage the learners to identify further questions as they conduct the analysis. They could add these questions to a table, where they write down their questions and the answers they get from each video (categories for analysis).

5. If the learners are analysing the videos in groups, they can define a guideline for making notes, to clearly define which information might be of relevance.
6. If they watch all videos together, they can discuss while watching which information is relevant and note it down.
7. You can help the learners develop a template, in which they can add their research questions. This will help the learners record all relevant data in the appropriate category.
8. Once the "coding" is complete, ask the learners to review the data and try to identify patterns and synthesize conclusions (e.g., define the trends in cotton production and processing, the steps and time taken in the production process).

Contribution to Systems Thinking competence

You can use this method to help learners understand a topic better and to help them realise that a "simple thing" may be embedded in a complex system with various elements and interrelationships, which can change over the time (dynamics of a system).

The method may be used in Step 5 (anticipating the future) or Step 6 (evaluating the impact in the frame of sustainable development) if suitable videos or podcasts are available.

Example

In Step 3 of the potato chips example, learners are asked to analyse selected videos on the production as well as the digestion of potato chips.

Visualisation

Suitable for Step 3 of the Jeans and Chips examples

Duration
Depends on the task

Material needed
Can be done by hand or using free software such as those used for concept maps or causal diagrams
https://www.xmind.net/
https://www.mindmup.com/
https://coggle.it/

Group Size
Individual or pairs

Objective

To help learners visualize concepts, components, and their relationships, and represent them graphically.

Visualizing is a method of learning (especially supporting exploration of a topic and integration of concepts) and expression that allows one to structure their knowledge of complex topics. It uses words, logos or pictograms as symbols of interrelated components and arrows to show interrelationship.

Description

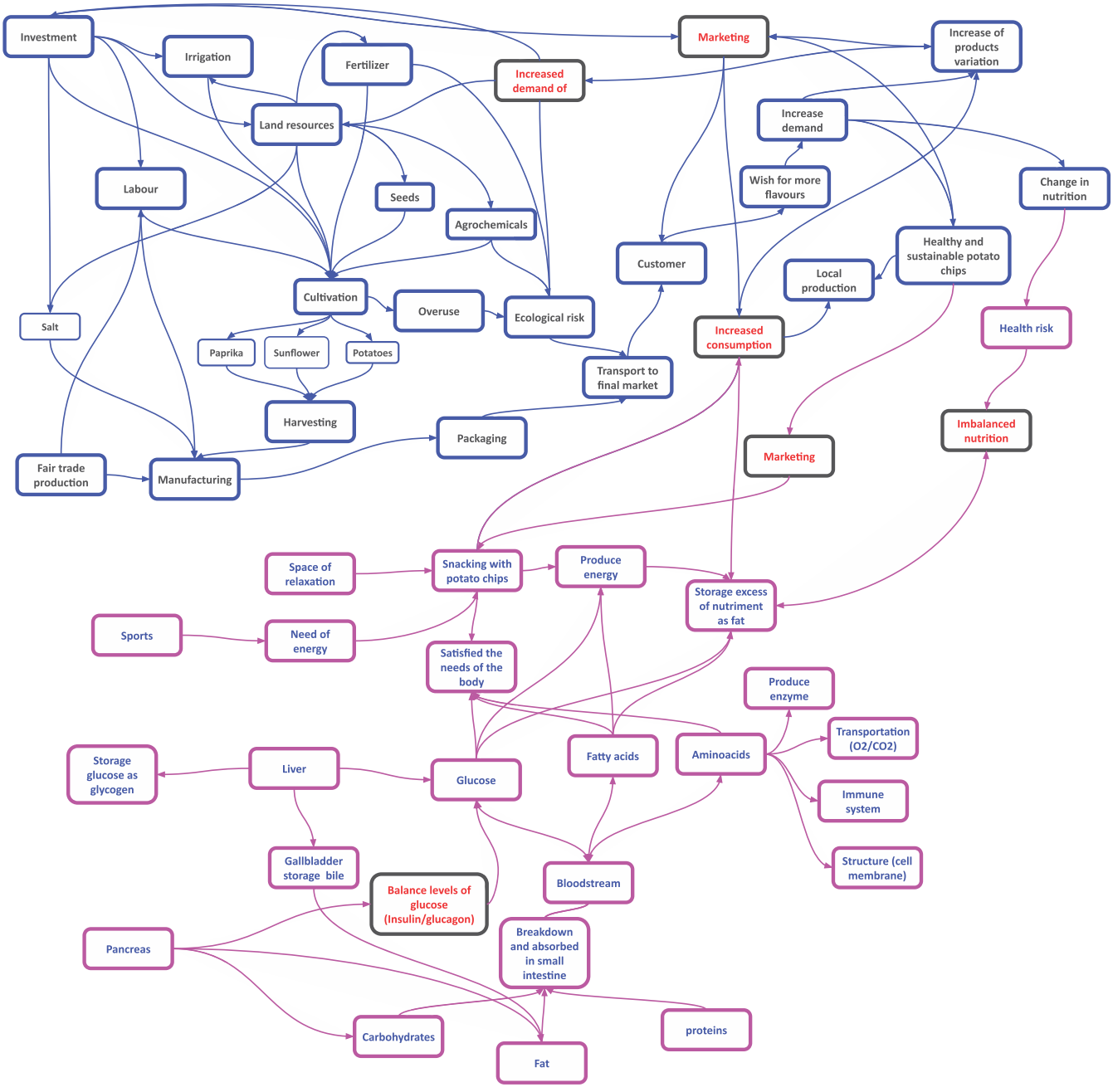
1. Ask learners to gather the important information about their selected topic. They should identify the main idea or question.
2. Then, they need to decide which form of visualisation is most appropriate for the topic. This depends on the purpose of the organization of the information and its representation. For example:
   a. To prepare a hierarchical structure of multiple sub-topics and further sub-ordinate elements, a mind-map might fit best.
   b. To show reasons and consequences of a process, a causal map may fit best.
   c. To depict a process, a timeline-oriented form, like a flow chart will be suitable.
   d. If the description is about the components of a situation, processes, impacts, and outcomes, then a model might be the appropriate form.

Contribution to Systems Thinking competence

Visualizations can help present or highlight those elements that seems more relevant, point out which relationships show the highest causality, and what is the direction of the relationship.

Visualisation helps to depict complicated and complex situations or processes by reducing and arranging elements and showing interrelationships between them, which helps us to understand them more easily.

Example

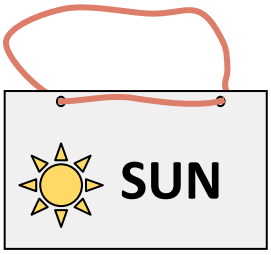


Further reading

Horan, Pat (2000). *Using rich pictures in information systems teaching.* Available at http://ceur-ws.org/Vol-72/039%20Horan%20SSM.pdf

Monk, Andrew, and Steve Howard (1998). The Rich Picture: A Tool for Reasoning About Work Context. Methods & Tools. *Interactions.* March-April 1998. Available at https://www.ics.uci.edu/~wscacchi/SA/Readings/RichPicture.pdf

Web of Life



Suitable for Steps 2, 3

Duration
30 to 45 minutes

Material needed
Name cards (as many as the number of learners)
Safety pins (same number as cards) or string to wear the cards
Ball of string (at least 250 m)

Group size
30 to 35

Objective
To demonstrate the interconnectedness of various elements in the environment.

Description

1. Based on the list provided at the end, make a set of cards with the names of the animal/ bird/ plant/ resource, etc. The learners can illustrate these cards.
2. There should be as many cards as there are learners. Cards can be made of chart paper cut into rectangular pieces of about 5 x 8 cm. A safety pin can be put through the top of each card or use a strong string to wear the cards.
3. Make sure to include and distribute cards depicting the four main elements of nature: Sun, Soil, Air and Water.
4. Ask the learners to sit in a circle.
5. Take the ball of string and give it to the learner who has the Sun card. It is appropriate to begin with the Sun because all life is made possible by it. Let the learner symbolizing the Sun loop one end of the string around her or his finger and pass the ball of string to any aspect of nature that the learner feels is related or connected to. For example, the 'Sun' may pass it on to 'Tree' because the 'Sun' gives energy to plants or trees. The learners should state the reason why she feels related to this element.
6. The 'Tree' then winds the string once or twice around her or his finger after ensuring that it is not loose between the 'Sun' and her or him. The learner symbolizing the 'Tree' then passes it to another aspect he or she feels related to, e.g., 'Fruit'. So, the line of relationships continues as the ball of string unwinds and begins to form a pattern which the learners/learners hold together. The ball of string is thus completely used.
7. Ask the learners to see the web-like effect of the string.
8. Then ask them to raise the web chest high. Let them hold it tightly so that if the web is pressed down it does not sag and touch the ground. Ask the learners to observe, feel and note this.
9. Ask the learners what would happen if some of these elements were destroyed. Let the learner representing these elements drop the string. Notice the visual effect. More elements may be dropped to dramatize the effect.
10. Now press the web down. It would probably touch the ground because it is loose. Ask the learners what would happen if the Sun or the other three major elements of nature were disturbed.
11. Conclude the game by explaining to the learners how inter-relationships and interconnectedness exist and why they are important.

Example

1. Sun
2. Air
3. Water
4. Soil
5. Tree
6. Fruit
7. Parrot
8. Algae
9. Fish
10. Eagle
11. Turtle
12. Insect
13. Frog
14. Mosquito
15. Lizard
16. Leaf
17. Rat
18. Butterfly
19. Ant
20. Student
21. Grass
22. Dead leaf
23. Earthworm
24. Root
25. Shrub
26. Seed
27. Fungus
28. Dragonfly
29. Monkey
30. Spider
31. Snake
32. Mongoose
33. Kingfisher
34. Washer man
35. Woodcutter
36. Buffalo
37. Honey
38. Honeybee
39. Squirrel
40. Moss
41. Grasshopper
42. Plastic bag
43. Deadwood
44. Paper
45. Crocodile

Contribution to Systems Thinking competence

Web of Life may help learners to understand interconnections between different elements in an ecosystem, or a social-ecological system.

When trying to develop a systems map, it may help to identify missing elements.

Resource

To see a demonstration of the Web of Life watch Paryavaran Mitra. (2012, May 15). T*he Web of Life: Classroom Environmental Education Activity.* [Video] https://www.youtube.com/watch?v=Fivc08jK2OE

INFORMATION SHEETS

Information sheet

What is a model?

For Step 2 and 3

A model is a simplified picture or depiction of a part of reality. The aim of preparing a (scientific) model is to clarify and organize one's own thinking and make it shareable with others.

To generate a model, identify relevant components or elements and (inter)linkages of a chosen part or situation of reality (i.e., your topic), that conveys or expresses what you perceive about the topic at that moment.

You might use different kinds of models such as graphical models to visualize the topic, or conceptual models to strengthen understanding about the topic.

For example:

- Globe – a 3D model

  A globe is a model of the much more complex real world. But the globe allows us to understand the position of the continents and oceans, gives us an idea of the arrangement of mountain ranges, rivers, or states etc. The globe helps us get some understanding of the earth, which, in reality, is a very complex system!
- Water Cycle – a graphical model

  The global water cycle is a well-known model. It visualizes the transpiration of water over the oceans and the condensation of water vapour in the form of clouds. These clouds cause precipitation over the oceans and, driven by winds, also over land. Precipitation feeds ground water, as well as surface waters like creeks and rivers, which finally end up in the oceans again.
- An equation is a conceptual model The Pythagoras theorem states that the area of the square whose side is the hypotenuse (the side opposite the right angle) is equal to the sum of the areas of the squares on the other two sides. The theorem is written as an equation, $c^2 = a^2 + b^2$, where c represents the length of the hypotenuse and a and b the lengths of the triangle's other two sides.

How to make a model?

Models can be simple or complex. To design models as successfully as possible, we should follow Albert Einstein´s advice:
"Everything should be made as simple as possible, but not simpler."

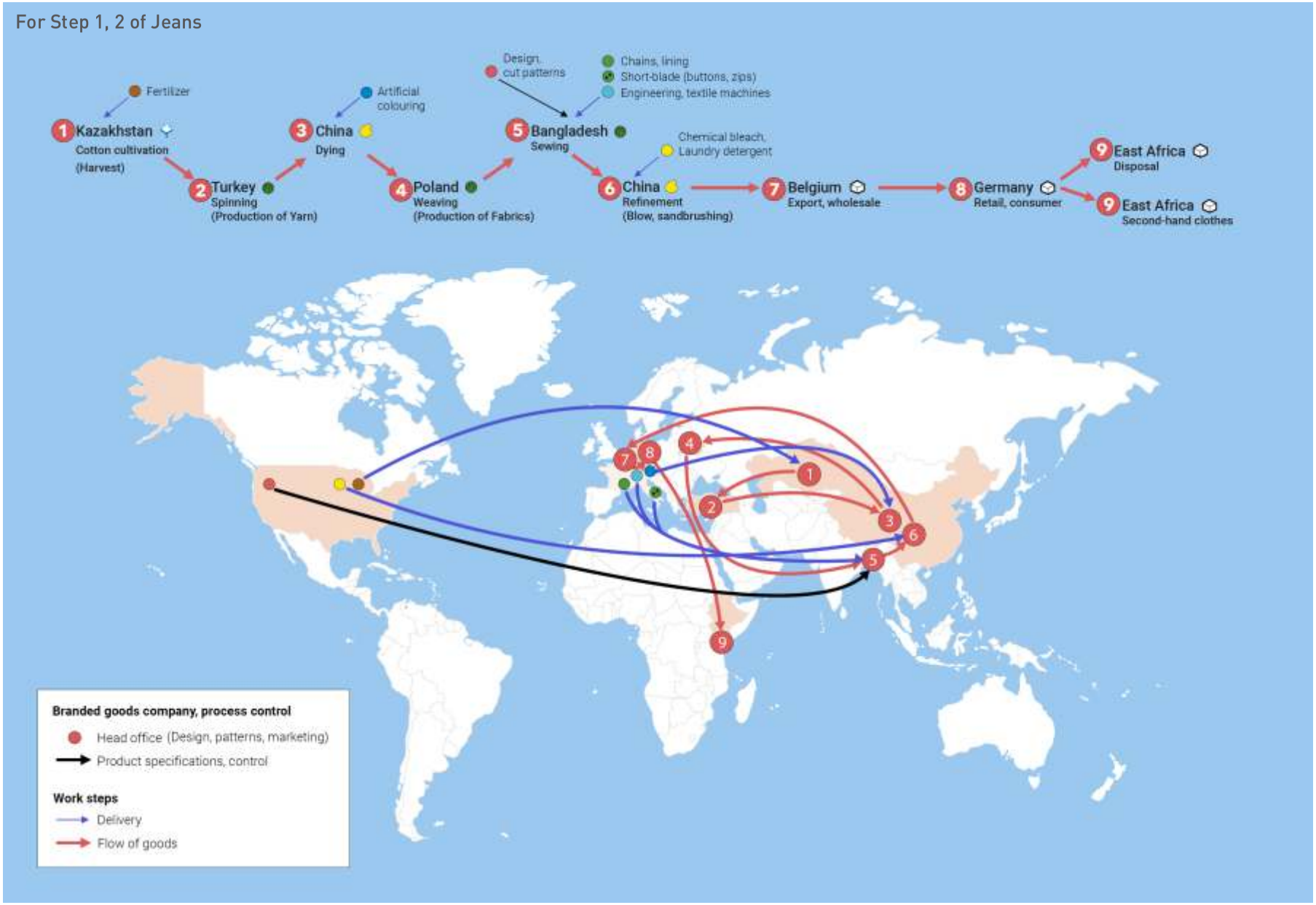
Visualizing is one of the ways to help create a model. It allows one to structure knowledge of complex topics. It uses words, arrows, logos, or pictograms as symbols of interrelated components of the given topic.

Steps to design a model

1. Describe the intended purpose of the model
2. Collect necessary information
3. Evaluate which pieces of information are in a causal relation to others, and therefore necessary to understand the chosen topic. You might have to convert specific information into abstract terms or icons.
4. To create the model,
   a. Give it a heading
   b. Arrange the elements in a logical order of time, levels, or spatial or geographic positions, as appropriate for the chosen topic
   c. Use icons where suitable and prepare an explanatory legend.

Information sheet

Global Value Chain of Jeans



Based on Westermann Gruppe (u.d), Globale Warenketten (am Beispiel Jeans) - 978-3-14-100800-5-271-4-1 available at https://diercke.westermann.de/content/globale-warenketten-am-beispiel-jeans-978-3-14-100800-5-271-4-

Information sheet

What is Sustainable Development (SD)?

For Step 6

To understand what "sustainable development" means, one may start by reflecting on the meaning of the conjoined words. So, "sustainable development" refers to a process that finally leads to the intended aim "sustainability". To get an idea about and understand what "Sustainable Development" means, we have to have clarity about the term "Sustainability". Therefore, our explanation starts with the question, what is the meaning of Sustainability?

In Europe, the concept of a process being sustainable came up in the beginning of the 18th century in the context of forest and mining. It was realized that there will always be enough wood as long as you do not cut more wood than can grow in the time that it takes to cut the wood. This 18th century concept provides us with a basic idea, if not a clear understanding of "sustainable development".

In 1987, the World Commission on Environment and Development (Brundtland Commission) Report, Our Common Future, described sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

An explanation of the difference between sustainable development and sustainability as suggested by UNESCO is:
Sustainability is often thought of as a long-term goal (i.e., a more sustainable world), while sustainable development refers to the many processes and pathways to achieve it (e.g., sustainable agriculture and forestry, sustainable production and consumption, good government, research and technology transfer, education, and training, etc.).

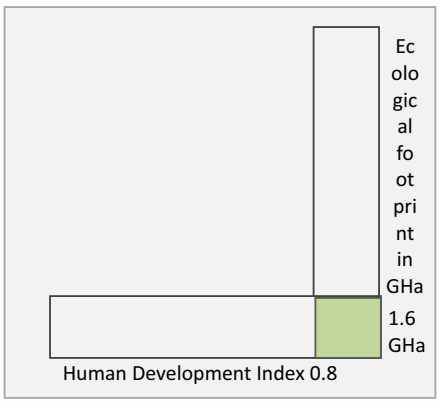
A much clearer concept of sustainability is presented with the interplay of the human development index (HDI) with the ecological footprint (EF) which defines sustainability in a mathematical, and therefore measurable, way.

According to this model, a social group or society may be sustainable when their HDI score is above 0.8 per capita, which indicates a high standard of living, while their ecological footprint is less than 1.6 global hectare (gha) per capita.

Based on that we can state:

S = HDI →0.8 + EF← 1.6 gha

S = sustainability
HDI = human development index
EF = ecological footprint
gha= global hectare



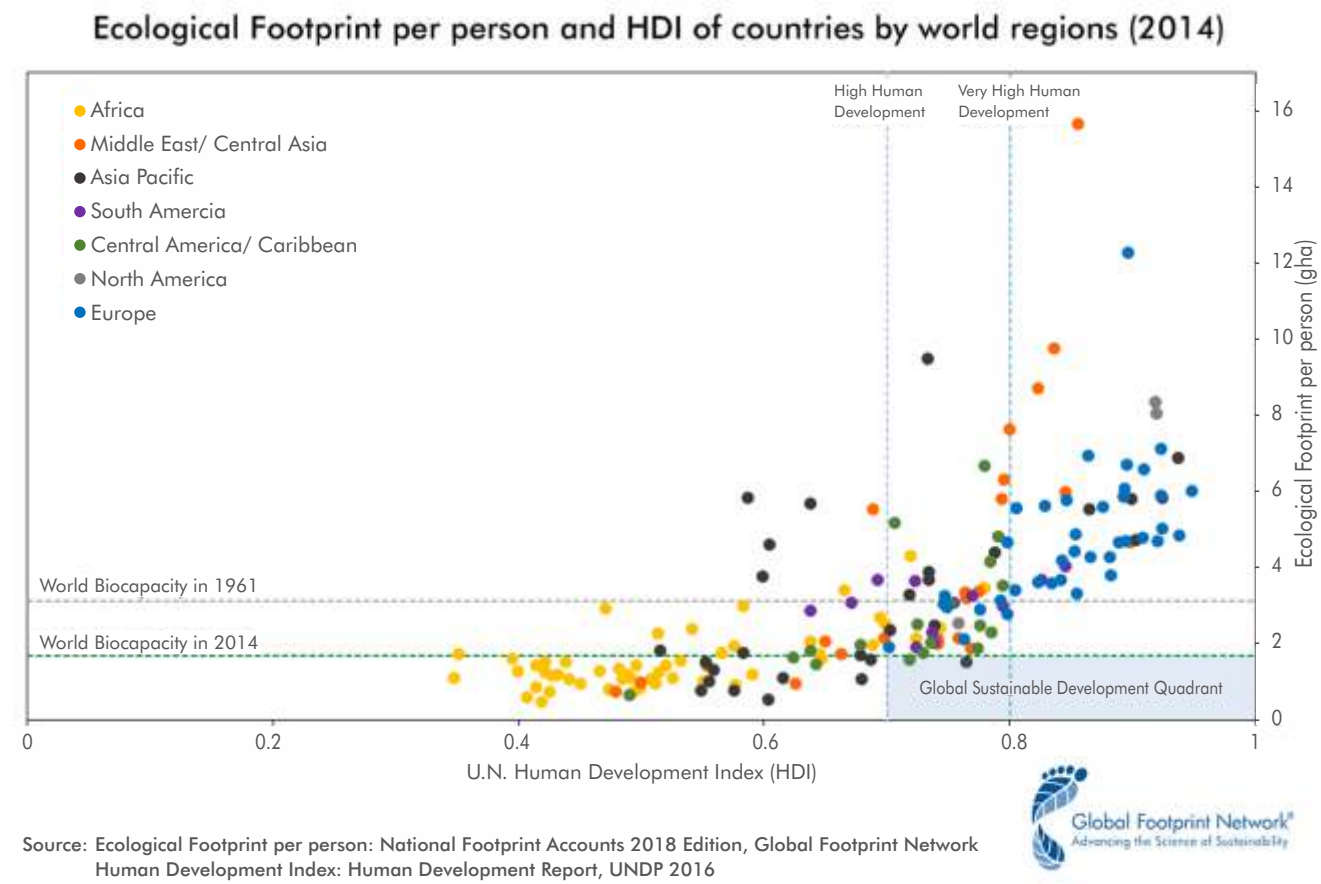
Model of Sustainable Development

What is "sustainable development"?

Based on the above description of sustainability, what sustainable development means is easy to deduce: sustainable development describes the process by which individuals and/ or social groups achieve sustainability.

Or, to use the same metaphor, sustainable development is the path leading into the green corner of the model – no matter where an individual, social group or a country starts.

- Sustainable development for several African and Asian countries means the increase and improvement of their HDI while keeping a low ecological footprint.
- On the other hand, for majority of the "Developed World", sustainable development means the decrease of their ecological footprint while keeping their high standard of living, measured as HDI.
- For middle income countries, sustainable development means an increase in their HDI score and a decrease of their ecological footprint.



Source: Ecological Footprint per person: National Footprint Accounts 2018 Edition, Global Footprint Network
Human Development Index: Human Development Report, UNDP 2016

Tasks

- Explain the idea of "sustainability".
- Explain the concept of sustainable development.
- Find out the HDI score and ecological footprint data of your country.
- Locate the position of your country on the HDI and EF graph and trace the path to the point of sustainability.
- List some ideas to support the sustainable development of your country.

Information sheet

Leverage Points

For Steps 7, 8, 9, 10

Leverage points are places in a system where, "a small shift in one thing can produce big changes in everything" (Meadows, 1999).

The picture below depicts the use of a lever to move the weight (represented by the big block). It is easier to use a lever to move the weight, meaning, you have leverage. The placement of the fulcrum and the point of application of force (green arrows) in this physical system influence the ease by which the weight would be moved. In human-made systems, leverage is about the efficiency and efficacy of interventions for changing the systems in accordance with desired goals. A leverage point is the place in the system structure where the intervention is made.

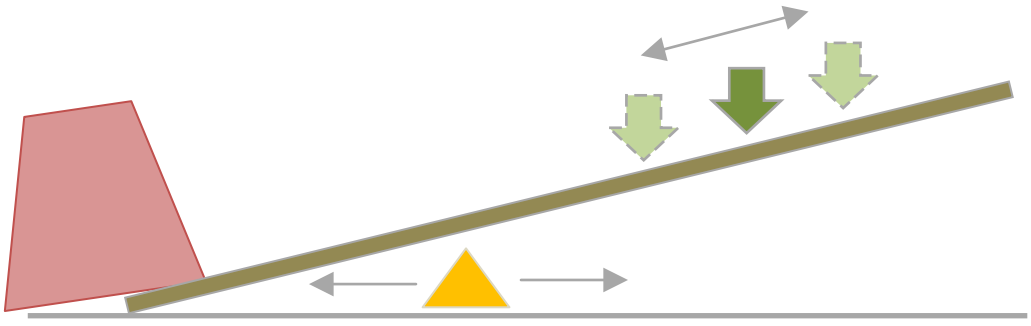
Types of leverage

Leverage may be present in the physical aspects of the system, in the interrelationships between the elements such as information, feedback, communication and rules. Human beliefs and paradigms that construct and shape human systems are potentially the most powerful leverage to change system behaviour.

Examples of leverage points and interventions

System infrastructure
• Add constraints
• Change rates
• Increase buffers
Information flows
• Modify feedback loops
• Expand communications systems
Organizing principles
• Change the rules that govern the system
• Enhance the organization of the system
• Align shared goals
Mindsets
• Modify the beliefs that guide behaviour in the system
• Expand the system's ability to transcend paradigms

Based on Ehrlichman (2018).



Examples of leverage points and interventions in the Jeans and Chips systems

System infrastructure	Examples from the Jeans system to reduce environmental impact	Examples from the Chips systems to reduce adverse health effects
• Add constraints	Ban GM seeds	Ban chips with high trans fat
• Change rates	Add an incentive to drop off old jeans for recycling/Encourage users to skip buying one trousers every year	Charge a premium on chips in the school canteen
• Increase buffers	Add organic matter to soil / Add an incentive to drop off old jeans for recycling	Mark one day every week or fortnightly as "chips day" - the day when one can have chips in limited quantities
Information flows		
• Modify feedback loops	Highlight the carbon footprint of jeans	Highlight long term impacts of overconsumption of chips on one's health.
• Expand communications systems	Create opportunities for customers and designers to interact with each other	Create opportunities for students to interact with sustainable food practitioners, dieticians
Organizing principles		
• Change the rules that govern the system	Create legislation that requires the use of recycled metals for zips, rivets	Reward students and parents who eat homemade food / sustainable food in the school.
• Enhance the organization of the system	Encourage alternative fashion and/or materials (e.g. use of Khadi/Handloom materials)	Organise sustainable food festivals in the schools where sustainable food practitioners teach sustainable food recipes to students, parents and teachers
• Align shared goals	Add environmental responsibility across the supply chain	Make parents, teachers and school management aware of the fact that giving younger generations a healthy lifestyle is their shared responsibility
Mindsets		
• Modify the beliefs that guide behaviour in the system	Promote the desire for sustainable, ethical jeans	Promote "Tasty is not always Healthy" campaign in the schools
• Expand the system's ability to transcend paradigms	Move to decentralized, diverse clothing with shorter value chains	Enjoy eating other healthier foods, Make the impact of eating healthier foods visible to all actors in the system

WORKSHEETS

Worksheet

Brainstorming

For Steps 1, 2 of the Jeans and Chips examples

Using the descriptions (or videos or stories) about the chosen topic prepared in Step 1, learners may try to classify the different items in their descriptions as elements, interrelationships, dynamism, and functions, which are part of the systems vocabulary.

Word table - Select words from the description; match these words to the systems components.

Rivets	Element
Cotton	Interrelationship
Thinking that jeans are 'cool'	Dynamism
Market price of cotton	Function
To produce clothing for people	

Potatoes	Element
Consumer preference for plain salted chip	Interrelationship
Changes in chip sales	Dynamism
To produce profit for the company that owns the chips brand	Function
Chips	
Salt	

Worksheet

Analyse your Model

For Step 2 of the Jeans example

Activity

- Use the table to analyse your model.
- Consider each aspect given in the left column and write your answers in right column.

Model introduction	**Your model**
What is the theme of the model?	
Who has developed the model?	
What type of model is it? (E.g., abstract, theoretical, equation, 3D, etc)	
What is the message of the model, or what does the model represent?	
Which geographic area and time does the model apply to?	
Model description	
Which elements are shown?	
What patterns and relationships are present?	
What are the key messages?	
Model explanation	
Explain the behaviour of the system over time	
Describe the boundary of the system in focus in the model	
List any sub-systems presents in the model	
Model testing/evaluation	
Do the main features of the model match the relevant aspects of the original situation that is depicted? Are they similar?	
Is the model appropriately simplified and clearly presented?	
Does the model enable precise descriptions, explanations, and predictions of the original situation in accordance with its purpose and give cause for thought?	
What are the limits of the model?	
Does the model need to be revised or discarded?	

Based on Bette, Julian Martina Mehren and Rainer Mehren (2019): *Modellkompetenz im Geographieunterricht Modelle als Schlüssel zum Weltverstehen.* In: Praxis Geographie, No. 3, p. 5

Worksheet

Words to Signs to Words

For Step 2 of the Jeans example

What is the meaning of a sign? In the first part of the table translate the signs into words. Now in the last part define a sign that identifies the words. Having got a sense, identify key words for your topic and define their signs.

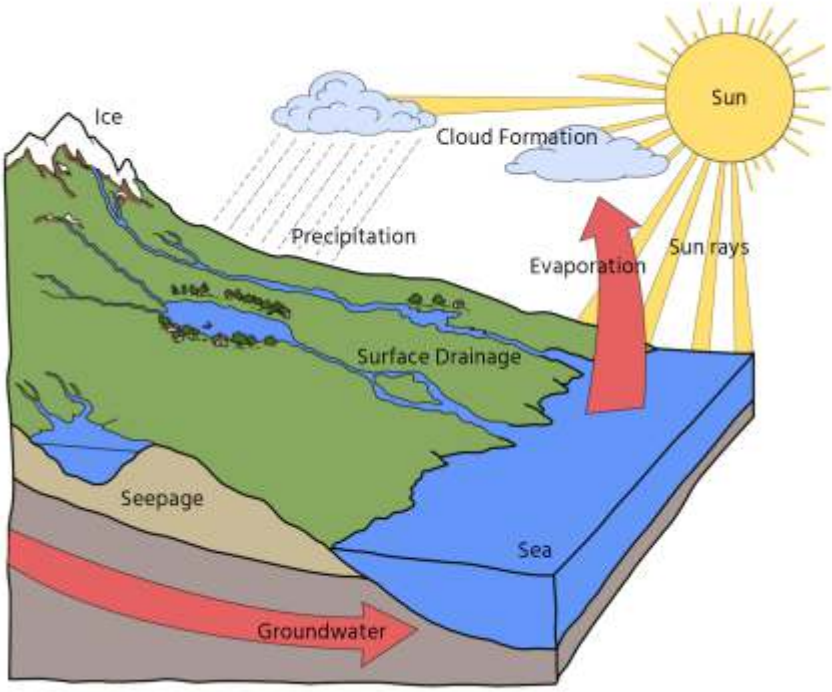
Sign / symbol	Meaning / word
	palm tree, oasis
	cactus, desert
	asteroid, danger
	world
	drop, water, oil
	crane, harbour
	arrow, means
	
	
	money
	potato
	cotton
	factory
	world trade

Worksheet

Transfer reality to model

For Step 2 of the Jeans example

1. Carefully analyse the model, its components and what it is trying to show.
2. Identify the elements of the model in the photo.
3. Put a transparent sheet or tracing paper over the photo.
4. Outline the main elements (e.g., mountain range, sea, building…) using tracing paper or transparent sheet.
5. Take the photo away and compare the new model you have drawn of the given model.



Worksheet

Cotton: Sustainable or unsustainable?

For Step 6 of the Jeans example

- Read the action in the Activity column. Decide if the activity is sustainable or unsustainable. Give reasons for your decision.
- Add more examples, share, and discuss within your group.

Sustainable	Activity	Unsustainable
	To irrigate vast cotton fields, water supply has to be increased annually.	
	The fact that the cotton production industry will grow might create even more jobs than today in this economic sector.	
	Modern cotton production depends on the use of specific seeds in combination with fertilizers.	
	Production of organic cotton will increase in the next 10 years.	
	Huge monoculture production of cotton weakens the soil fertility which leads to an increasing use of agro-chemicals.	
	Increasing use of technology leads to improved workers conditions.	
	The future need of cotton is satisfied with GMO cotton.	
	Increasing use of agro-technology saves money and lowers expenses for the producer.	
	Cotton exports improve the economic situation of countries like India and strengthen social development.	
	Fair trade cotton offers better income and living conditions for small scale farmers and laborers.	
Add three activities		

Worksheet

Potato Chips: Sustainable or unsustainable?

For Step 6 of the Chips example

- Read the action in the Activity column. Decide if the activity is sustainable or unsustainable. Give reasons for your decision.
- Add more examples, share, and discuss within your group.

Sustainable	Activity	Unsustainable
	Eating more chips produced from potato starch and not fresh potatoes	
	Growing demand for potato chips will create more jobs in farming and transportation sectors	
	Organic production of natural ingredients for potato chips will grow in the near future	
	Schools organise their own catering service for lunch / mid-day meal	
	The increased development of new flavoured chips improves the economic situation in countries like India and strengthens social development	
	More countries in the world import chips from leading production countries to serve the need for lunch snacks/ mid-day meal	
	Only potato chips of several flavours are served as school lunch or mid-day meal	
	Supply chain law will lead to better income and living conditions for small-scale farmers	
	Marking the Nutri-Score on chips packets will influence consumer decisions towards more healthy snacking	
Add three activities		

Worksheet

Measuring Development

For Step 6

The 2030 Agenda for Sustainable Developmentis a plan of action for people, planet, and prosperity. It also seeks to strengthen universal peace. We recognise that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development. All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are resolved to free the human race from the tyranny of poverty and want to heal and secure our planet. We are determined to take the bold and transformative steps urgently needed to shift the world onto a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind. The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals (MDGS) and complete what these did not achieve. They seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental. The Goals and targets will stimulate action over the next nine years in areas of critical importance for humanity and the planet.

Gross domestic product (GDP) is a monetary measure of the market value of all the final goods and services produced in a specific time period. GDP (nominal) per capita does not, however, reflect differences in the cost of living and the inflation rates of the countries; therefore, using a basis of GDP per capita at purchasing power parity (PPP) is arguably more useful when comparing living standards between nations, while nominal GDP is more useful comparing national economies on the international market.

Ecological Footprint measures the demand on and supply of nature. On the demand side, it adds up all the productive areas for which a population, a person or a product competes. It measures the ecological assets that a given population or product requires (including plant-based food and fibre products, livestock and fish products, timber and other forest products, and space for urban infrastructure) and to absorb its waste, especially carbon emissions. The Ecological Footprint tracks the use of productive surface area. Typically, these areas are: cropland, grazing land, fishing grounds, built-up land, forest area, and carbon demand on land. On the supply side, a city, state or nation's biocapacity represents the productivity of its ecological assets (including cropland, grazing land, forest land, fishing grounds, and built-up land). These areas, especially if left unharvested, can also serve to absorb the waste we generate, especially our carbon emissions from burning fossil fuel.

The Human Development Index was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone. The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. The health dimension is assessed by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. The standard of living dimension is measured by gross national income per capita.

Sources:
https://en.wikipedia.org/wiki/Gross_domestic_product;
http://hdr.undp.org/en/content/human-development-index-hdi; https://www.footprintnetwork.org/our-work/ecological-footprint/; https://www.handprint.in/our_vision; https://sdgs.un.org/2030agenda

Analysis Matrix for Development Measures

'Measuring Development' presents four different approaches to estimate or measure the development of countries and societies.
Use this table to analyse the four approaches (GDP, HDI, EF, SDG) for their suitability for sustainable development of societies or nations.

Measuring system	What is measured?	How is it measured?	Does the tool help you understand development of a state or society?	Does the tool help you understand the dimensions of sustainability of a state or society?
Gross Domestic Product (GDP)				
Human Development Index (HDI)				
Ecological Footprint				
2030 Agenda				

Worksheet

SDG Analysis Matrix

For Step 6 and 10 of the Jeans example

- Mention the name of the system or topic you are analysing in the heading row.
- Get well versed with SDGs. Read the 17 SDGs and the 169 targets. https://sdgs.un.org/goals
- Identify elements in the system that contribute to or are counter to one or more Sustainable Development Goals (SDGs) or targets. Write your conclusion in the first or second column, as appropriate.
- If you find that a specific element contributes to one SDG but runs counter to another SDG, record it in the third column, mentioning what the dilemma is.

SDG Analysis Matrix for the System

SDG	Element contributes to SDG	Element counters the SDG	Element is a dilemma for SDGs
			
			
			
			
			
			
			
			
			

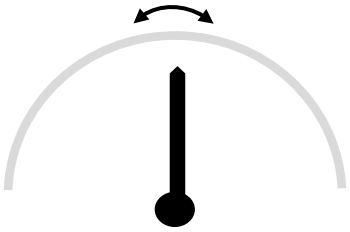
			
			
			
			
			
			
			
			

Worksheet

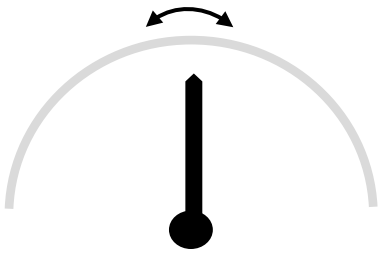
Using the Leverage

For Step 7 of the Chips and Step 8 of the Jeans examples

Think about the different directions of change possible at the leverage points you have identified. List the actions and consequences in the table.



Action/ Consequences	Leverage point	Action/ Consequences
	Land resources used for cotton cultivation	
	Source of metal for zips (Using metal from mines or sourcing recycled metals)	
	Soil degradation/ management	
	Desire for jeans "Ethical jeans" (e.g. made from organic cotton and recycled metal) or "regular jeans" or even a preference for unbranded plain cotton trousers)	



Consequences	Leverage point	Consequences
No overuse of agricultural land/ resources • limited yields • stable or declining production • natural soils • recovering soil biodiversity • good quality of ground water • ...	**Risk of over-use**	Overuse of agricultural land/ resources • short term increase of yields • in the long run (permanent) degradation of soils, reduced yields necessitating increased investments in agrochemicals • water shortage • contamination of groundwater due to agrochemical overloads • competition between potato and other food production on valuable agricultural land
	Desire for chips	
	High Yielding Varieties (HYV) of potatoes	
	Genetically Modified (GM) potato	

Worksheet

Sustainable Jeans?

For Step 8 or 9 of the Jeans example

- In this step you have to identify possible and effective leverage points to turn the global cotton and jeans production more sustainable.

Tasks

- Visit the Ellen Macarthur Foundation's Jeans Redesign webpage https://www.ellenmacarthurfoundation.org/our-work/activities/make-fashion-circular/the-jeans-redesign?utm
- Analyze the video on this webpage from the perspective of sustainable / unsustainable jeans production.
- Answer the following questions.

Questions

1. Why has cloth production become unsustainable in recent years?

2. Which steps of jeans production are unsustainable?

3. Why does cotton-based cloth have a potential to contribute to a sustainable world?

4. How can we change cotton and jeans production towards sustainability?

GLOSSARY

2030 Agenda for Sustainable Development: Contains the 17 Sustainable Development Goals (SDGs) with 169 targets which were framed and unanimously adopted by the 193 member states of the United Nations on 25th September 2015.

Anticipatory competence: The abilities to understand and evaluate multiple futures – possible, probable, and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes. (UNESCO, 2017).

Balancing behaviour/loops: Along with reinforcing loops, it forms the two building blocks of dynamic systems. Balancing processes seek equilibrium — they try to bring things to a desired state and keep them there. They also limit and constrain. A balancing loop depicts a balancing process. Also called negative loop. (Lannon, C., 2016).

Behaviour of the system: The behaviour of a system are the expected changes over time, as long as it is allowed to function normally. For example, the seasons are a normal behaviour of the climate system (Lannon, C., 2016).

Collaboration competence: The abilities to learn from others; to understand and respect the needs, perspectives, and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving. (UNESCO, 2017)

Competence: Competences are specific attributes that individuals need for action and self-organization in various complex contexts and situations. They include cognitive, affective, volitional, and motivational elements. Hence, they are an interplay of knowledge, capacities and skills, motives, and affective dispositions. The different competences cannot be taught but have to be developed by the learners themselves. They are acquired during action, on the basis of experience and reflection. (Weinert, F. E., 2001)

Critical thinking competence: The ability to question norms, practices, and opinions; to reflect on own one's values, perceptions and actions; and to take a position in the sustainability discourse. (UNESCO, 2017).

Ecological Footprint: A measure of the pressure that humans exert on the planet. It is expressed in global hectares (gha), or by number of planets, and it allows us to estimate the land surface needed by each individual to provide for their needs. (Selectra, 2021).

Education for Sustainable Development (ESD): ESD generally focusses on the development and strengthening of individual competencies, enabling the individual to contribute to and participate in sustainable development processes of various kinds and dimensions. From that definition it is obvious that all types of competencies and skills including basic competencies such as reading, writing, numeracy are included. Higher level competencies such as creativity, solution-oriented thinking and actionability are fundamental for ESD, since without them it would not be possible to find ways, concepts, techniques, which make us succeed to reach the space of sustainability. (ESD Expert Net, 2019).

Feedback loops: The return of information about the status of a process. For example, annual performance reviews are a way of returning information to an employee about the status of his/her work. (Lannon, C., 2016).

Flow: The amount of change something undergoes during a particular unit of time. For example, the amount of water that flows out of a tub each minute, or the amount of interest earned in a savings account each month. (Lannon, C., 2016).

Global (Production) System: The potato chip example navigates the journey from the potato field to the bag of chips in our hands as part of a global production system.

Global citizenship education: GCED is a concept which explains how students can be equipped with knowledge, social skills, values, and attitude to better understand the world and its complexities, to gain values, attitudes and social skills which help them to develop affectively, psychosocially and physically, to enable them to live together with others respectfully and peacefully and to contribute actively to a better world. (UNESCO, 2018)

Gross Domestic Product (GDP): Gross domestic product (GDP) is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period. As a broad measure of overall domestic production, it functions as a comprehensive scorecard of a given country's economic health. (https://en.wikipedia.org/wiki/Gross_domestic_product)

Handprint: The Handprint signifies positive action and commitment. It serves as a measure of human contribution to sustainability at the individual, community, national and global level just as the footprint is a measure of unsustainable human action. (Sarabhai et al., 2022).

Human Development Index (HDI): A statistic composite index of life expectancy, education (mean years of schooling completed and expected years of schooling upon entering the education system), and per capita income indicators, which are used to rank countries into four tiers of human development. A country scores a higher HDI when the lifespan is higher, the education level is higher, and the gross national income GNI (PPP) per capita is higher. (https://en.wikipedia.org/wiki/Human_Development_Index)

Integrated problem-solving competence: The overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive, and equitable solution options that promote sustainable development, integrating the above-mentioned competences. (UNESCO, 2017).

Interrelationships and causation: The language of systems thinking is circular rather than linear. It focuses on closed interdependencies, where x influences y, y influences z, and z influences x. (Lannon, C., 2016).

Leverage point: Leverage points are places in a system where, "a small shift in one thing can produce big changes in everything" (Meadows, 1999).In human-made systems, leverage is about the efficiency and efficacy of interventions for changing the systems in accordance with desired goals. A leverage point is the place in the system structure where the intervention is made.In the physical world, 'leverage' occurs when an input of force into a system generates a greater output force. Leverage is about relative efficiency and efficacy of possible interventions. A 'leverage point' within a system is that point where you place your 'lever' to cause the maximum intended impact, with a minimum of input, such as efforts or funds. (Lannon, C., 2016).

Normativecompetence: The abilities to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions. (UNESCO, 2017).

Recognizing, Evaluating and Acting: The ´Ten Steps towards Systems Thinking´ are arranged along the dimensions Recognizing, Evaluating, and Acting (UNESCO, 2017, p. 91 and Schreiber/Siege, 2016, p.95). The steps begin with simple description of reality (recognizing), leading to progressive, comprehensive, and deeper analytic understanding (assessing/evaluating), and therefore preparation to act more strategically (acting).

Reinforcing behaviour/loops: Along with balancing loops, it forms the two building blocks of dynamic systems. Reinforcing processes produce both growth and collapse — they compound change in one direction with even more change. A reinforcing loop depicts a reinforcing process. Also known as vicious cycles or virtuous cycles and positive feedback loops. (Lannon, C., 2016).

SDGs/UN Sustainable Development Goals: Are the heart of the 2030-Agenda which aims to ensure that all human beings can lead a life in dignity within the means of this one planet.

They represent a systemic, problem-solving, future- and action-oriented approach to social change towards a more sustainable world that is applicable to both developed and the developing countries.

Self-awareness competence: The ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires. (UNESCO, 2017).

Stock: A structural term for anything that accumulates, e.g., water in a bathtub, savings in a bank account, current inventory. In the stella modelling software, an accumulator is used as a genetic symbol for anything that accumulates. (Lannon, C., 2016).

Strategic competence: The abilities to collectively develop and implement innovative actions that further sustainability at the local level and further afield. (UNESCO, 2017).

Sustainable Development: Sustainable development describes the process of individuals and/or social groups to achieve sustainability. Or, to use the same metaphor in the context of the interplay of HDI and ecologic footprint, sustainable development is the path leading into the green corner of the model – from wherever an individual, social group or whole nation started. (ESD Expert Net, 2019).

System boundaries/Boundary: A system is an interconnected set of elements that is coherently organized in a way that achieves something. A system is a system when it consists of the following: elements, interconnections, and a function or purpose. Systems show typical behaviours or patterns of change such as causal or feedback loops, growth, or decay (reinforcing) in linear or exponential manner, or oscillations, or stabilising (balancing) behaviour. (Lannon, C., 2016).

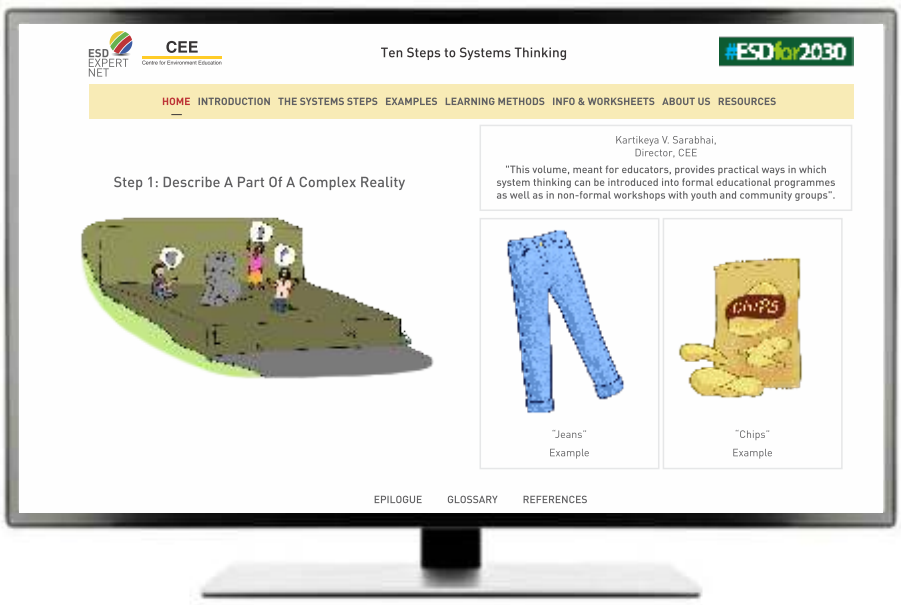
Systems models: A model is a simplified picture or depiction of a part of reality. The aim of (scientific) modelling is to clarify and organize one's own thinking and make it shareable and communicable to others (Lannon, C., 2016).

Systems thinking competence: The abilities to recognize and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty. (UNESCO, 2017)

Systems Thinking for Sustainable Development: Is the ability to describe and/ or visualise a part of a complex reality, express that part of reality as a model, understand the model as a system, use the model to explain the behaviour of the system, anticipate the behaviour of the system, and evaluate its impacts on sustainable development, identify potential points of, and types of interventions, generate options to act, assess their impacts in the frame of sustainable development, and decide whether further actions are necessary or not.

The Ten Steps: Are arranged along the dimensions Recognizing, Evaluating, and Acting. The Steps start with simple descriptions of reality to a progressively more comprehensive and analytic understanding, and therefore preparation to act more strategically.

Transformative learning: Transformative learning is the idea that learners who are getting new information are also evaluating their past ideas and understanding and are shifting their very worldview as they obtain new information and through critical reflection. It goes beyond simply acquiring knowledge, and dives into the way that learners find meaning in their lives and understanding. This kind of learning experience involves a fundamental change in our perceptions—learners start to question all the things they knew or thought before and examine things from new perspectives to make room for new insights and information.



Online version of this resource is available at https://www.ceeindia.org/systemsthinking/

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