Appropriate Application of Three Systems Thinking Methods: Cognitive Thinking, Design Thinking and System Dynamics

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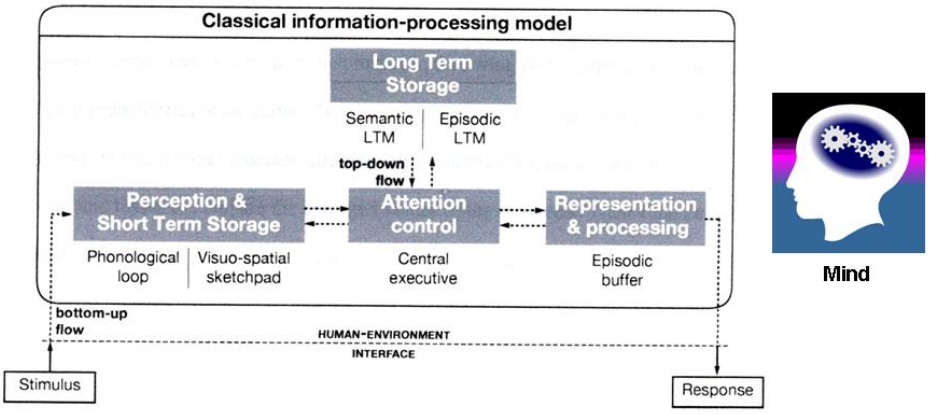
Systems Thinking is big picture thinking. However, there are many different ways of taking the big picture into account. This study includes a discussion about the type of context(s) that are the best fit for each of these three Systems Thinking Approaches. It also will examine the pros and cons of each of these methods, and describe situations/ settings where each method is useful.

In order for Systems Thinking to be as useful as possible, it must be applied properly. This presentation will help participants to understand these three methods, identify when to apply each one, and broaden their comprehension of the value of nuances when using Systems Thinking.

When it comes to the actual application of Systems Thinking, the context makes a difference. Different approaches work better for different situations. While Cognitive Thinking, Design Thinking and Systems Dynamics are all very useful for Systems Thinking, each has its best fit type of application.

Cognitive Thinking was thought to be a result of linear processes in the more traditional, classical thinking model. In this case a problem stimulus would be mentally processed to produce a cognitive result. This kind of thinking was then expanded to include both deductive and inductive processing loops. These processes allow for transformative actions which result in new inputs which form the next processing loop. (See Visual 1 below.)

Classical Cognitive Model



Visual 1

(From Gaelle & Frederic Vallee-Tourangeau, Copyright March 2017, & Dr. Julia Taylor, Copyright 2023)

Cognitive psychologists held a strong assumption about how cognition occurs, essentially that people receive information, process it, and produce a response such as an answer to a problem, a judgment or a choice. This caused a problem because

cognitivists put a disproportionate emphasis on the head and mental processes, operations and computations at the expense of behavior and its "situatedness". On the other hand, the behaviorists reduced the workings of the mind to the associations between stimuli and responses. Both perspectives were found to be lacking.

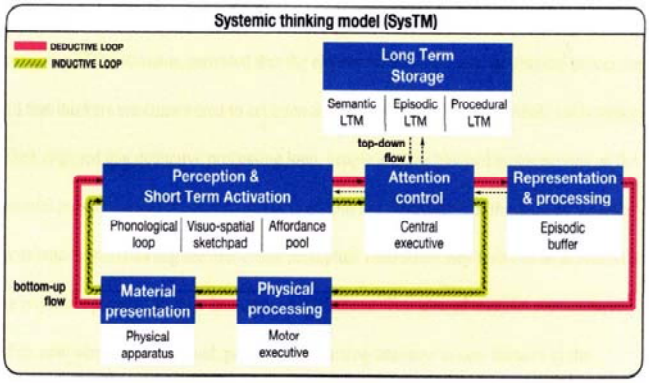
Another view to explain how people actually think is based on the concept that people are able to think better when they can manipulate information both in their mind through mental processes and in their immediate environment through hands-on manipulations. One proposed theory contends that such manipulations really do make a difference as to how people actually think. (Vallee-Tourangeau, 2017)

When you consider this in light of how humans in early childhood learn and grow, you realize that it has to be true. How can children learn so much so fast? It is because they engage all of their senses (not just their eyes and ears) through a process of trial and error discovery. How we came up with the notion that this would not apply later in life is perhaps the mystery. Humans are able to develop capabilities for abstract thought, which was not possible as a child, yet that doesn't mean that the original capabilities suddenly went away.

The Classical Information-Processing Model (See Visual 1) assumes that there is a deductive flow of information in cognition where actions and behaviors are the end product of the application of intuitive or deliberate cognitive processes to the mental equivalent of the sensory input. Study results indicate that mental processes (such as memorization, mental arithmetic and visuospatial reasoning) depend on mental resources. The classical assumption that responses are inferred or deduced from mental processing depends on the individual. (Weber, 1978) The classical information-processing model is adequate as long as one seeks to account for cognition arising from an information processing pathway where a unique final action, response or behavior is deduced from the processing of a mental representation. It has the shortcoming of precluding the conception of the thinking process as evolving through a series of actions which will inform and transform a concurrent mental processing of the task information. It also does not allow for the next action, response or behavior to be induced from action possibilities offered by the immediate environment rather than deduced from mental processing.

A newer theory is proposed by the researchers (Vallee-Tourangeau, 2017) which is about meshing mental processing with transformative actions of a thinking agent on the immediate environment. In addition, that agent has the benefit of a working memory that includes various action possibilities. In this approach, unplanned actions can transform mental processing and augment cognitive performance. The key for this is to move away from viewing "the mind as the processor" vs "behavior as the reaction" and instead focus on the nexus between mind and behavior, which the researchers call *cognitive interactivity*. They call this model the "Systemic Thinking Model". (See Visual 2) It includes some additional elements as compared with the "Classical Thinking Model", essentially it includes consideration of the environment and physical elements of interacting which are not part of the classical model. As mentioned earlier, this model includes the elements that allow children to rapidly learn how to function in the world. It acknowledges the benefit of those early learning techniques. It also represents a movement away from reductionism and towards holism.

Enhanced Cognitive Model



Full Body

Visual 2

"Classical accounts of thinking put too great an emphasis on internal representation and mental processes and ignore the symbiotic relationship between thinking and acting." (Vallee-Tourangeau, 2013) These researchers believe that thinking emerges in an ecological space and an ecological time due to a transactional flow of action and mental representational opportunities that come out of a dynamic action-environment interface. This means that thinking happens in the context of a system that encompasses the brain and the body within a particular environment and most importantly the spatio-temporal dynamics that occurs there. (Vallee-Tourangeau, 2013)

The best example to illustrate this that I can think of is about how the fictional character, Jessica Fletcher, in the murder mystery series, "Murder She Wrote", goes about solving crimes. During her day-to-day activities, she often stumbles upon key clues to the mystery in such mundane objects as napkins or cigarette lighters or jewelry. She actively seeks out information from suspects, from crime reports and information, and other sources, but those are not usually responsible for her cracking the crime. Instead it is her ability to piece mundane clues together, based on the behavior of the suspect and those associated with the suspect, that makes the difference in solving the murder. Her act of interacting with the physical environment represents a key factor in her success.

According to a recent article, "Cognition includes all of the conscious and unconscious processes involved in thinking, perceiving, and reasoning. Examples of cognition include paying attention to something in the environment, learning something new, making decisions, processing language, sensing and perceiving environmental stimuli, solving problems and using memory." (Cherry, 2023) This description opens the door to a much wider concept than the early views about cognition would entertain. This means that Cognitive Thinking encompasses a whole lot more than was originally

thought. This is good news because it means that human capabilities go far beyond what can be most simply quantified and explicitly explained.

One of the greatest systems thinkers of all time, Leonardo da Vinci (1452-1519), had this to say, "These are the principles for the development of a complete mind: Study the science of art. Study the art of science...Realize that everything connects to everything else."

Waqas Ahmed (2019) believes that Leonardo would have been particularly interested in holistic philosophies which would characterize thought outside of European specialised thought, and thought in which the rigid procedures of empirical data are less prevalent and less dominant. We in the West tend to value empirical data far more than more generalized thought, but does this really make sense? Ahmed talks about how in Ancient India, philosophers called Jain philosophers developed a mode of thinking referred to as *Anekantaveda*, which teaches the existence, appreciation and potential simultaneous validity of different perspectives.

Leonardo sought to expand the environment of his thought. He pursued this by engaging in a method of enquiry sparked by curiousity that included discovering, pursuing, experiencing and knowing multiple perspectives, then synthesizing them together in a way that created a more complete picture of the world.

The philosopher Edward O. Wilson said this about uncovering reality, "Only fluency across the [disciplinary] boundaries will provide a clear view of the world as it really is...A balanced perspective cannot be acquired by studying disciplines in pieces but through pursuit of the consilience among them." (Wilson, 1998)

Systems Engineering has that versatility of using a number of models and perspectives including functional, systems architecture, business process, and enterprise model. This ability to use different perspectives is not necessarily present in all disciplines, yet is very valuable. It may become more useful in the future by incorporating more human related domains into the approach and expanding the scope of the discipline.

Cognitive Thinking (for Systems Thinking) is a skill that can be applied without using specific frameworks and methodologies. This allows for broader application and makes it easier for those who are not specifically trained in certain methodologies, to use Systems Thinking and apply it to their work. Chowdhury (2023) introduced this notion of more loosely applying Systems Thinking in order to gain greater acceptability and usage of this skill. He also introduced the term Holistic Flexibility which is about using flexibility in both intent and form when it comes to applying Systems Thinking through cognitive thought.

Chowdhury demonstrated this application through two separate use cases. One was a public relations firm with offices in Bengaluru, New Delhi, and Mumbai, India. It offered services for companies involved in consumer, healthcare, technology and social innovation. The company experienced rapid growth and needed some kind of change to allow for intra-firm collaboration and adaptable business services.

The outcome included changing the location-based structure to an industry-based structure, implementing new collaboration methods via advanced technology so that teams could work across geographical regions, and shifting the role of HR from transactional processes to providing training and other programs to support transformation.

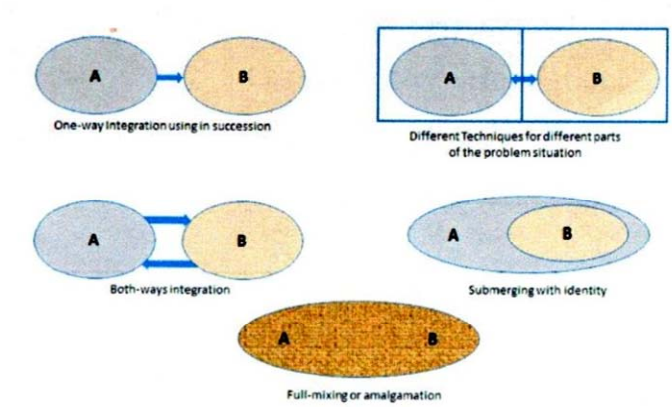
The second use case involved a steel manufacturing company that served 150 countries around the world. The company emphasized new product development and growth. However, customers were not happy that the company was divided into silos that worked as separate departments and not as an integrated team. In addition, there wasn't enough cooperation between sales, production and delivery in order to get the orders delivered as promised.

The outcome included creating a new organizational structure that would steamline operations, shifting the team from a transaction focus to a value focus that emphasized customer needs instead of internal boundaries. They introduced a new approach to capability building so that employees could advance. Finally, they introduced a behavior competency framework in order to help improve employee skills for the long run.

At first glance, both of these outcomes seem reminiscent of those from a typical Harvard Business School case study, which means its easy to believe they are good quality recommendations, yet not particularly innovative. However, the overall approach, the level of participation of the key stakeholders, and the level of connectedness of the recommendations really could represent a greater degree of innovation and more importantly--usefulness for the intervention.

The overall approach takes advantage of Cognitive Thinking (for Systems Thinking) which is applied without having to be bound by the rigor of any particular methodology. It applies Holistic Flexibility which practitioners can adopt in order to implement Systems Thinking as a state of mind or conceptual lens. Using Holistic Flexibility allows for the use of a mixture of methodologies which can be integrated in different ways. (See Visual 3) The most highly integrated approach: Full-mixing or amalgamation involves a seamless application method which is really one overall approach.

Methods for Integrating Methodologies

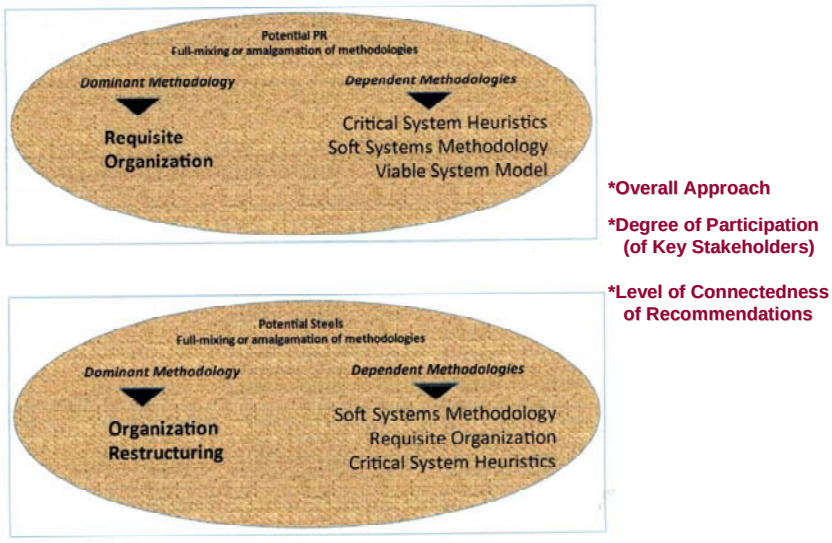


Visual 3

These interventions used a number of different methodologies which engaged the client at different levels of the organization which opened the door for potentially, a high level of engagement of key stakeholders.

The overall approach brings connectedness into the picture from the beginning, when the ideas are being formulated, as well as in the process of designing the unfolding of the implementation plan. (See Visual 4) Here you see, in each case, that the practitioner has identified a dominant methodology and the supporting dependent methodologies. These mixed methodologies all work together to implement the changes needed to fulfill the desired transformation at each of these organizations.

Full Mixing of Methodologies for Two Case Studies



Visual 4

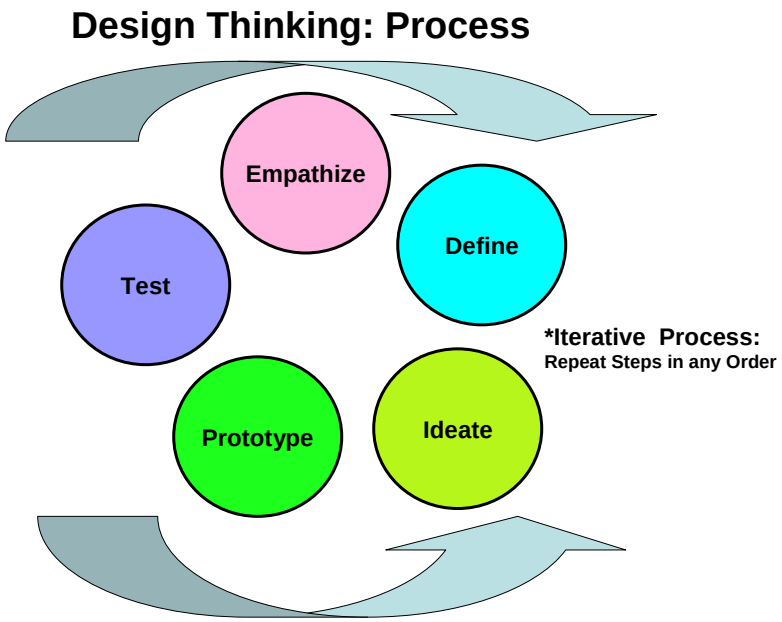
(From Chowdhury, Copyright April 2022,Dr. Julia Taylor, Copyright 2023)

These examples show that Cognitive Thinking works very well for complex situations with many stakeholders, many somewhat different agendas, many different skill sets, and when multiple methods are needed for implementation. It allows key players to adopt a big picture perspective, yet enables them to integrate different functions and processes together in order to achieve overall goals.

The second Systems Thinking method that will be discussed is Design Thinking. Design Thinking is a process that is used for designing goods and services as well as strategies and strategic initiatives. Higher level Design Thinking, such as that used to create strategies, can be thought of as almost synonymous with Systems Thinking. In many ways, they are the same because they both involve looking at the Big Picture and deliberately thinking about ways to design "whatever is being created". Traditionally, Design Thinking has been used primarily by product designers to create products that better serve customers. This means that although the overall thinking process may involve Systems Thinking, there is a definite push towards the immediate creation of a tangible, functional product. It is usually focused more on short term results than on something long term, like strategy.

Design Thinking involves the following steps: Empathize, Define, Ideate, Prototype, and Test. These steps are repeated iteratively as needed, not in any

particular order, until the desired result is achieved-- a working prototype. (See Visual 5) Design Thinking is not a new concept and it is not a concept reserved for creating small things either. Proponents claim that monuments, bridges, vehicles, and subway systems are all examples of creations that came out of Design Thinking. However, my thinking is that it's more likely that new versions of these creations were produced by Design Thinking, not the original.



The Eames company started creating chairs in the early 1900s using Design Thinking and they still produce new chairs which satisfy customers. This focus on customer requirements also helped Jean Muir, a clothing designer, to succeed using Design Thinking.

A key tenant of design thinking is to consider "the whole". What a lot of companies failed to consider was the desires of the people using their product, so companies that do this stand out from those that don't.

Empathize is all about understanding the customer. This means both speaking to actual customers and observing their behavior and understanding what they think, what they want, what their motives are and what their frustrations are.

Next you have to define the problem explicitly in ways that you can incorporate innovation and create a new solution. Research the problem and figure out how the information can help with the solution.

Then come up with as many new ideas, no matter how crazy, as possible. The goal of this step is to identify as many options as possible. Create a diverse set of possibilities to consider.

Next, create a prototype. This is a visual demonstration of at least a portion of the concepts involved. You want to know what can work and what will not work. Get feedback from other people about the prototypes. Modify the prototype based on the feedback.

Build it and test it on actual users. See if this actually fits what they wanted. Eventually, after a number of iterations, an innovative new product can begin to take shape.

One way that the Design Thinking process is useful is when the scope of an innovation is small enough that it can be grasped easily and when there are sufficient opportunities for adopting alternative perspectives. Then it's a matter of getting past prior mental blocks and trying new possibilities. This works when the solution is actually an existing possibility, rather than a revolutionary concept that does not exist.

However, Design Thinking has a much broader application when you think about it from the standpoint of thinking instead of the simplified process (described above). Hvidsten, Rai and Todnem (2023) stated that it is more than solving design and innovation problems. They say that it presents a mindset, methods and tools that have the potential to help with organizational change. They think that Design-led organizations embed design throughout the firm and work to make the culture design oriented by sparking curiosity, cross-functional empathy, brand expression through design and influencing values, norms and assumptions about how people work in the organization. These methods seem foreign to managers and engineers due to the non-linear format for working together, yet the very format itself is what allows for more creativity and imagination in solutions to problems. Design can make a unique contribution towards strategic goals and so it should be articulated so that everyone understands this and these individuals should be included in cross-functional teamwork.

Design Thinking is a method used by companies such as GE Healthcare, Netflix, and UberEats for problem solving and to develop effective solutions to challenges. GE Healthcare used this approach to improve a product that they used for serving children in diagnostic imaging. Many children became very upset with the imaging process and were observed crying in cold, dark rooms with flickering fluorescent lights. The redesign effort focused on making the machines have a theme like "Pirate Adventure" which transformed the machine into a pirate ship with beaches, sand castles, and the ocean. This redesign not only made the patients 90% happier, but it also improved the scan quality and saved time and resources for the staff. This illustrates a great example of incremental innovation.

In another example Oral B sought to upgrade its electric toothbrush. The company wanted to add more functions such as tracking brushing frequency, observing gum sensitivity and playing music. However, the designers employed to do this work found that users did not want additional functionality. They wanted the toothbrush to be easier to charge and more convenient. The company then produced a much simpler toothbrush that was cheaper and didn't need to be recharged. This was much more successful than what they had in mind would have been.

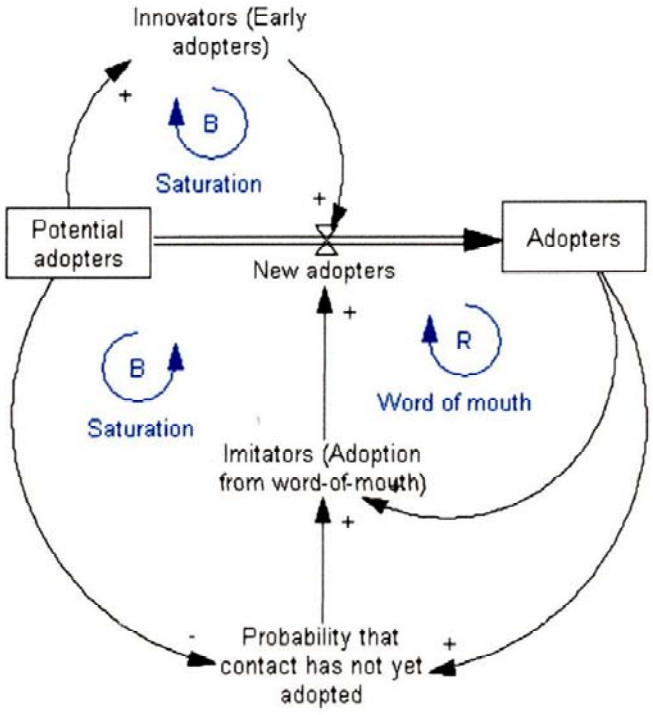
In yet another example Airbnb used Design Thinking to solve the critical problem that not enough people were using their service. They were initially only making about $200 a week. The founders came to the realization that hosts were posting low quality, uninviting pictures that were too low in quality to attract customers. They then empathized with customers and decided to invest in a high quality camera and take pictures themselves of the places they were trying to sell. This way they were able to show every room, highlight special features like hot tubs, and show the customers what the neighborhood was like as well. A week later their revenue doubled. Their use of

Design Thinking-- and putting themselves in their users shoes, gave them the solution to their business problem. (Han, 2022)

System Dynamics is a method of Systems Thinking that concentrates on understanding how the objects in a system interact with one another. A system can be anything from a car engine, to a bank account, to a well-functioning economy.
Jay Forrester (1961) initially defined System Dynamics as the investigation of the information-feedback characteristics of systems and the use of models for the design of improved organizational form. The objects and people in a system interact through "feedback loops" such that a change in one variable affects other variables over time, which then affects the original variable.

An example from System Dynamics illustrates the process of new product adoption. (See Visual 6) In this depiction there are two stocks: Potential Adopters and Adopters with one flow. For every new adopter, the stock of potential adopters declines by one while the stock of adopters increases by one.

New Product Adoption Model

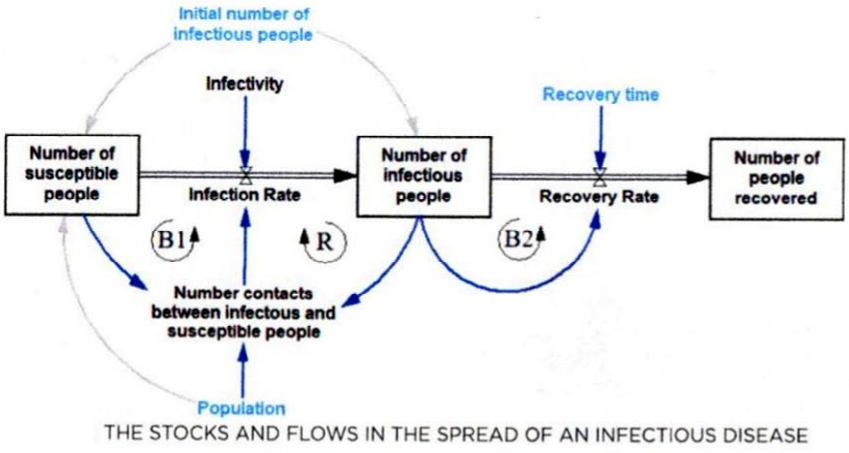


Stock and flow diagram of *New product adoption* model

Visual 6 (From Wikipedia, System Dynamics, Copyright 2023)

Another example shows the spread of an infectious disease. (See Visual 7) In this case it may be important to identify how severe the daily spread of the disease is. The movement from susceptible to infectious is controlled by the number of new infections that happened that day or the rate of infection. (Onggo, 2021)

Spread of An Infectious Disease



Visual 7

(From: Onggo, Copyright 2021)

System Dynamics works well for certain types of problems, including those just mentioned. It works well for tracking the rate of adoption of a new product, tracing the severity of the spread of a disease, tracking the interdependencies between wolf and elk populations in Yellowstone, managing a factory and making decisions about the timing and amounts of various inventory quantities, reducing energy usage in an automobile factory, and supply chain management of food chains.

These are situations where the relationships of "what causes what" can be identified and quantified. These situations represent contexts that are workable for using Systems Dynamics to answer certain pertinent questions that help manage specific problems and factors for maximum benefit.

Now the discussion will switch over to looking at the pros and cons of each of these methods, with particular emphasis on the cons or drawbacks that you have to take into account if you want to apply them properly.

Cognitive Thinking (for Systems Thinking) is a very versatile and adaptable approach for Systems Thinking which can be very useful, especially when it's a complex situation like a business challenge that requires that a number of different types of issues be addressed. (See Visual 8)

As shown in Visual 8, this approach allows the implementers to be free from rigid rules of methodology and it allows for very flexible application of the concept. There are endless possibilities in how this type of thinking process can be used and manifest itself. It works well in that it allows implementers to function well in a dynamic and evolutionary environment. It also allows for learning and adapting to new circumstances. Cognitive Thinking provides leaders with new tools that can be used in order to involve and engage stakeholders at higher levels than is typical. It helps implementers to have greater capabilities for taking action and bringing about actual results. Finally, it supports deeper insights because it involves people in a more complete way and makes it possible to have better interactions across functions.

Cognitive Thinking (for Systems Thinking)

Pros

*Freedom from Rigid Rules of Methodology, & Flexibility in Application
*Open-ended in Possibilities for Expression
*Able to Embrace a Dynamic, Evolutionary Context
*Allows for Learning & Adapting to New Circumstances
*Empowers Leaders to Engage Stakeholders at a Higher Level
*Lends Capability for Pragmatic Action
*Supports Deeper Insights & Cross-Functional Interaction

Cons

*Resistance to Use of Less Structured Approach/ Credibility Challenge
*Filters such as Power Filter & Mentality Filter Can Obstruct Clarity
*Numerous Cognitive Biases (Ambiguity, Attention, etc.) Distort Process
*Erroneous Assumptions or Mental Blocks
*Skewed Perception/ Problems Entertaining Multiple Perspectives
*May Require Education & Training in order to Implement

Visual 8

The drawbacks of Cognitive Thinking include resistance to the use of a less structured approach and acceptance of this kind of approach as being a credible, viable approach. Individuals who participate can have filters that come into play, such as power filters or mentality filters which can obstruct the work process and muddy the goals. There are numerous cognitive biases which can distort the process of Cognitive Thinking. (See Visual 9) It's important to be aware of these biases and try to guard against them.

Human Biases (1 of 2)

Ambiguity Effect: Causes People to Pick an Option that they know has the probability of a good outcome, instead of selecting an unknown option.

Attention Bias: This happens when some information gets a disproportionate amount of a person's attention due to that person's history.

Anchoring Bias: This happens when a person's expectation about one things is affected by something they were aware of before, which may or may not be of the same significance now.

Availability Bias: This happens when someone's prediction about an event's probability is overly influenced by how easily they can recall examples of that event.

Bias Blind Spot: The tendency to see oneself as being less biased than other people would be.

Choice Supportive Bias: When someone has chosen between different options, then later on, decides that the choice had more positive attributes than it did at the time the choice was made.

Confirmation Bias: The tendency for people to seek out and give more weight to information that confirms their preconceptions.

Hindsight Bias: The tendency to perceive past events as being more predictable than they were before they took place.

Optimism Bias: The tendency to be overly positive about the probability of positive events while underestimating the probability of negative events.

Visual 9

Human Biases (2 of 2)

Control Fallacy: When a person views events as internally controlled they may put themselves at fault for events that are outside the person's control, such as another person's behavior. Also, if a person sees events as being externally controlled, this person might blame their boss for poor work performance.

Dunning-Kruger Effect: The inability to recognize your own lack of competence in an area.

False-Consensus Effect: Overestimating the degree to which other people agree with their judgments and approve of their behaviors.

Functional Fixedness: Happens when you see a hammer then view it as a tool for pounding nail heads. This is what hammers were designed to do, so this is how you view it. For instance, Hannah=IT, Alex=Marketing. This "fixedness" limits creativity and problem solving.

Halo Effect: Judging a person by a single characteristic, like beauty.

Misinformation Effect: When you remember an event, your perception of it can be altered if you later get misinformation about the event. This can cause you to change how you remember it.

Black & White Thinking: A dichotomous thinking pattern that results in seeing things in terms of either/or. A situation is good or bad, right or wrong, all or nothing. This king of thinking fails to acknowledge that there are almost always several shades of gray that exist between black and white. In fact, the middle ground is often the more reasonable position.

Self-Serving Bias: When something goes wrong in your life, you may have a tendency to blame an outside force for causing it, but you don't think this way if it's someone else.

Visual 9

Probably the worst drawback of Cognitive Thinking is that the actions required are not specifically prescribed by the method. (See Visual 10)

Cognitive Thinking Drawback

Visual 10

This means implementers may not know what to do. They may know that Systems Thinking includes consideration of patterns and flow, relationships, interconnections, feedback loops, and accounting for the big picture, yet they still may not know specifically what steps to take. They are not automatically spelled out. In addition, it's important to note that Cognitive Thinking (for Systems Thinking) may go against typical

control oriented, reductionist business thinking. If this kind of thinking has not been practiced previously, it may be difficult to get implementers to use it, even if they are familiar with the overall concepts.

Due to the existence of all of these biases, mental blocks and bad assumptions, people with emotional intelligence who have a high level of self-awareness and the ability to work well in teams are the people that are best suited for applying Cognitive Thinking. Teamwork helps people to see other perspectives and avoid the pitfalls of all of these problems when working alone. By focusing on the overall goal, the team is able to overcome problems that otherwise might derail the project.

Although Cognitive Thinking can free implementers from being bogged down by meticulous and laborious methodologies, still education and training may be needed in order to get everyone on board. Participants need to have an overall, basic understanding of Cognitive Thinking (for Systems Thinking) and be able to exercise it when working on projects.

Design Thinking also has certain pros and cons which should influence decisions regarding which type of process to use for Systems Thinking. (See Visual 11) Design Thinking is good when you want to take into account the users requirements and give particular attention to that. It's good to use when you need to get to an answer quickly and you have the pertinent information and talent in the room. This means that multidisciplinary teams can be especially effective in finding new solutions fast. Recently, Design Thinking has received favor as a tool for a much broader audience than it had traditionally. However, I believe that it is actually being used along with other tools for many of these broader applications.

Design Thinking

Pros

***Centered Around User Needs & Building Solutions for Them**
***Multi-Disciplinary Teams Are Very Effective in Finding New Solutions**
***Recently Expanded into Much Greater Usage & Application**
***Bottom Up Approach Can Speed Up Adoption**
***Iterative Approach Increases Likelihood of Prototype Being Optimal**
***Uses Available Information & Technology to Produce the Result**
***Reduces Risk of Creating a Product that Isn't Appealing to the User**
***Helps to Embed a Cultural Mindset Focused on Improvement**
***The Word Says it All: "Design" is about Applying Intent to the Result**

Cons

***Solutions Produced May Not Serve the Organization's Goals**
***Focuses on Producing a Tangible Result Too Quickly**
***Not Useful for Long Term or Radical Innovation with High Complexity**
***Resulting Creations Might Not Be Aligned with Corporate Regulations**
***Scope is Limited & Not Enough Depth for Giant Commercial Projects**
***Overlooks a Lot of Data that Might Turn Out to be Relevant**
***By Itself May Be Too Open-Ended & Lacking in Structure & Methods**

Visual 11

Since Design Thinking is implemented with those closest to the action, or from the bottom up, it can be adopted a lot sooner than it would if it originated at a higher hierarchical level. Due to the fact that it is an iterative approach, the likelihood that the

prototype that is produced is optimal, is a lot higher than it would be if the process was a straight through linear process.

Design Thinking typically takes advantage of the information and the technology that is readily available in order to produce the result. It does not entail a lot of steps to create innovation just from the idea itself, but instead relies upon the Design Thinking participants to rapidly create something. Because it uses information from the user or in some cases even includes the user in the process, the risk of creating a product that is not appealing to the user is greatly reduced.

When a company uses Design Thinking regularly, this can have the impact of embedding a cultural mindset that is focused on improvement. The Design Thinking process itself uses iteration in order make improvements.

Finally, Design Thinking is all about "Design" which means that it's about applying intent in order to produce a certain result. Putting consciousness into the creation process greatly improves the odds of ending up with a useful result.

There are, of course, some cons or drawbacks to using Design Thinking. First of all, the solutions that are produced may not serve the organization's goals if just the five steps are followed. There must be attention put into making sure that the product being designed is aligned with corporate objectives. That does not happen automatically.

The process is all about producing a result fast. It may turn out to be too fast if it leaves out considerations that are important, like how the product will be integrated with existing products or how easily the product can be made to adhere to industry standards or government regulations.

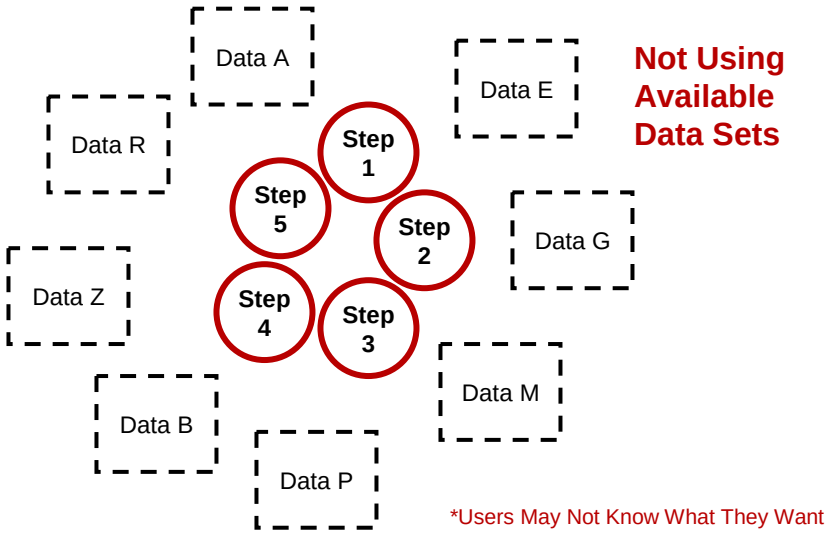
Due to its results focus, it may not always be the appropriate method. Long Term Innovation projects as well as Radical Innovation Projects may require use of pure research and may entail many steps, processes and projects that do not fit into a Design Thinking project. It is a fast focus type of process that does not allow for incorporating very high levels of complexity and high levels of integration and configuration within certain external parameters.

The result might not adhere to corporate regulations. Some industries have special requirements for safety or zoning laws or environmental concerns. For instance, nuclear products, some biotech products, and a number of industrial products that involve highly toxic chemicals.

The scope of Design Thinking using the five steps is limited in scope which means that it may not allow for the depth of discussion and exploration needed in order to accomplish some giant commercial projects. The pursuit of outer space and even aviation projects might require a lot more activity and direction than the five steps prescribe.

Design Thinking is a streamlined approach "on purpose". However, there are situations where data including big data and multiple industry databases may need to be used in order to achieve the goals of the project. (See Visual 12) Chemists, for instance, use massive databases in order to discover and create new drugs.

Design Thinking Drawback



Visual 12

This approach won't work well for every project. It may simply be too open-ended and lacking in structure and methodology to be able to do some projects. Many endeavors require adherence to specific disciplines that use a lot of precision in order to get results. It might be useful for a portion of the project, but not as the overarching method for the whole thing.

The last method of Systems Thinking that will be discussed in this paper is System Dynamics. It's useful to consider the pros and cons of using this method, before using it. (See Visual 13) System Dynamics is able to provide insight into complex systems when the goals are clear and the scope is well defined. There must be a specific purpose that is being pursued.

When it's done well, System Dynamics models show you an overall view of a situation including the key variables and the interactions between the variables. Key to the process is the feedback loops which show that the variables are connected. Having an overall view that shows what is going on, can help to manage key variables in order to produce the best outcomes.

By using a System Dynamics model, you can ask questions about a complex system and get answers to help refine that system. It serves as a useful tool for getting the system to perform in a desirable manner.

Using a System Dynamics model you can see what happens over time. Various interactions can be quantified so that you can see which variables have the greatest impact on the model as time goes on.

When teams across the company need to work together, a System Dynamic model can clarify what is happening and resolve conflict between teams. When everyone can see the overall picture, it makes it much easier to pinpoint where changes need to be made.

System Dynamics

Pros

***With Clear Goals & Scope, It Provides Insight into Complex Systems**
***Provides an Overall View of Key Variables & Their Interactions**
***Serves as a Useful Tool for Asking Questions about Complex Systems**
***Quantifies Interactions & Develops Time Dependent View of Behavior**
***Enhances Understanding Across Multiple Teams, Resolves Conflict**
***Helps with Decision Making & Policy Formulation**
***Both Qualitative & Quantitative Models Can Be Created**
***Helps Improve Systems & Reduce Risk Factors in Systems**

Cons

***A SD Model can only Run One Version of a Situation at a Time**
(Even though the Values of the Variables Can Change)
***Variables are Defined by People--so just as Subjective as Other Methods**
***Models Often End Up Overly Complicated-Don't Handle Complexity Well**
***Models Have Limited Focus & Scope & Work Best for Closed Systems**
***Subject to Biases & Assumptions of Modeler/ May Omit Relevant Details**
***Model May Leave Out Key Stakeholders & Discount Uncertainties**
***It's Easy to Build Non-Sensical Models without Meaningful Relationships**

Visual 13

System Dynamic models can help with making decisions because they show details that otherwise might be missed. Also companies may want to enact new policies and by using System Dynamics models they can identify how those policies should be constructed so that they accomplish the long term goals of the company.

System Dynamics models can be created for both qualitative and quantitative purposes. When facing a complex situation, the first questions will probably be about finding out what is going on in the system, so qualitative models can be very useful. Then later, you may want to decide more specifically what needs to be done to improve the system, so quantitative models can be helpful.

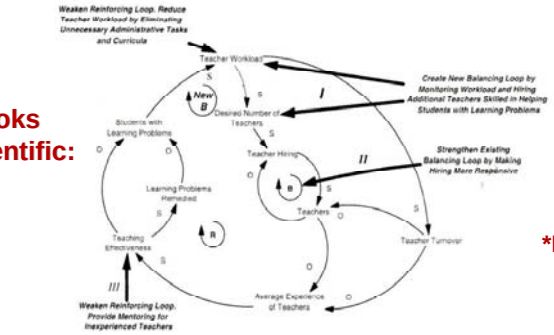
System Dynamics models can be used to reduce risk in a system or improve it so that it works more efficiently. An observer can see which factors may be the most risky and come up with ways to mitigate that risk.

System Dynamics models, when applied properly, can offer a lot when it comes to making the most of a complex system. It can save companies great sums of money and help people to prevent major problems from happening. This methodology can help save lives, maximize the use of resources, and help organizations make money.

As great as this method seems on the surface, it does have some major drawbacks. Perhaps the biggest drawback is that it can only run one version of a situation at a time. This can be very misleading for a novice. Inputs can be flawed due to human choices. (See Visual 14) Here you see a model about the problem of retaining teachers. It totally omits the variable regarding top administrators or any reference to the fact that the quality of the administrators is an issue. The values of the variables can change and provide a lot of different scenarios to look at, but these are all based on the one situation. What if that is the wrong situation? What if certain key variables are not connected with the other items in the model correctly? As a modeler, you have to make certain assumptions and set up the model in one particular way. This makes it prone to errors.

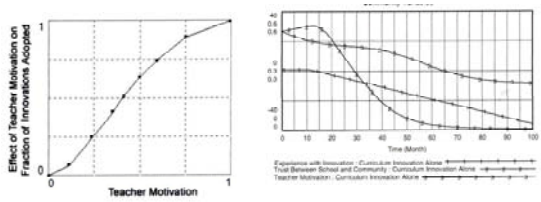
System Dynamics Drawback

Looks Scientific:



Can Be Deceiving!

***Inputs Can Be Flawed Due to Human Choices**

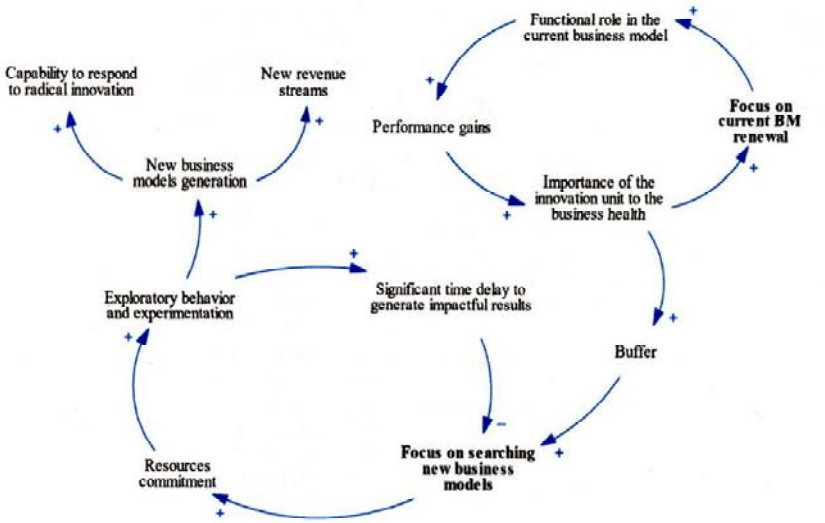


Visual 14 (Adapted From: Hirsch,Levine, & Miller, 2007, Dr.Julia Taylor Copyright 2023)

Similarly, the variables in the model are defined by people. They may not even be defined properly. They may have even omitted key variables. This knowledge illuminates us as to the fact that this method is just as subjective, and sometimes more so, as other methods. Bures, et al (2019) points out that one model describing milk production did not include cows as a variable. Therefore, this was not a sound model.

Next will be a presentation of two business examples using System Dynamics models, which seem incomplete because they don't accurately represent the real situation. (See Visual 15) Here you see a researcher's ideas about business model innovation (Franco, et al, 2023)

Shows Lack of Interaction with Main Activity



Buffer Serves as Mechanism for Exploratory Business Model Innovation

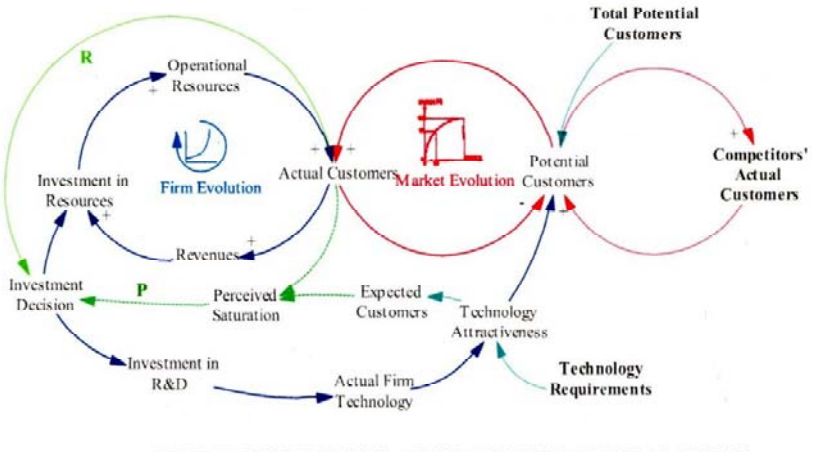
Visual 15 (From: Franco, Minatogawa, & Quadros, Copyright 2023)

The circle in the upper right hand corner is where the primary action is taking place. The problem is that there just isn't enough interaction of the rest of the model with this key segment where action is actually happening. This may accurately represent what a certain company is actually doing, but it falls short in terms of utilizing all this activity (shown to the left of the key circle) for the company's benefit. There's the "buffer" which represents all of the innovation activity, which is simply there if the company decides to use it, otherwise it is of no consequence. Another point is that the buffer only represents potential choices that could be made, and there isn't anything there about how it could be incorporated into the overall company--the key segment shown in the right-hand circle.

Another Systems Dynamics model attempts to show a particular company within the situation of the industry evolving with some new technology possibly being introduced. (Kunc, 2010) (See Visual 16) This shows a very limited perspective, somewhat stagnant view--not entrepreneurial. It depends upon reactive actions, not aggressive "create new markets" type of behaviors. It assumes that customers won't go for any new technology that is beyond their immediate requirements. It is "Dynamic" only to the extent that is allowed by the stable inputs. It appears to incorporate the biases of the modeler who sees the situation as rather flat, rather than being truly dynamic.

Models can sometimes end up overly complicated with way too much information being included. These kinds of models do not handle complexity well. In this case, the modeler needs to go back to the drawing board and find a way to construct it so that it reveals useful new information and not just a lot of white noise. It's a challenge to generate a model with enough detail to be effective without being overly clumsy.

Shows: Very Limited Perspective



Visual 16

(From: Kunc, Copyright 2010)

System Dynamics models are currently being used for all kinds of problems. Many of these are very open-ended and include many ill-defined variables. In addition, the purpose of the model may not even be all that clear. Models should only be to help people get a better grasp of a situation, not just show everything that can be shown.

In general, System Dynamics models work best for closed systems where the variables are well known and can be well defined. Also, "what causes what" should be clear, there should not just be a mish mash of causal links that can't be explained. These models have a limited useful focus and scope and should be used accordingly.

Not only are the variables subjective according to what the modeler thinks they are, but also the model is subject to the biases and assumptions of the modeler. Earlier a huge list of human biases was mentioned. (See Visual 9) These biases apply for creating System Dynamics models as well as for Cognitive Thinking. These biases can cause a number of problems, not the least of which is leaving out relevant details and information that is crucial.

In addition to leaving out information due to personal biases, modelers might also leave out information due to project biases like key perspectives that really should be represented in the model. For example, if the model is about a controversial drug, it doesn't make sense to only include information that supports the drug proponents. All well researched and documented information coming from all drug researchers should be included in the model. For similar reasons, key actors and stakeholders might end up being omitted from the model.

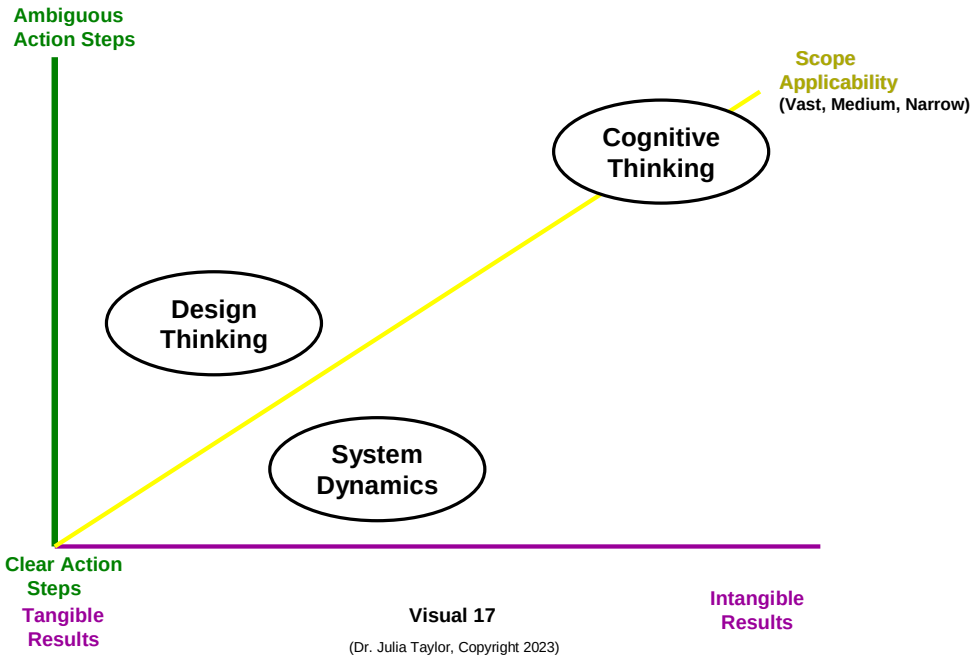
A model may leave out any mention of uncertainties that could make or break the outcomes of the model. These uncertainties should be included and considered as points of risk to be evaluated as part of the model.

Finally, it's important to note that almost anyone, whether trained or not, can create models these days with the software that is available. You don't have to know

anything about System Dynamics or Systems Thinking or any particular discipline, you can just use the software. The problem is that these may very well turn out to be non-sensical models that do not actually show any meaningful relationships, patterns or feedback loops. The direction of the flows could be wrong. The flow lines could be improperly weighted. There are so many ways one could go wrong in creating System Dynamics models, but with the software the kinds of errors one could make becomes exponential. Therefore, I would caution people using System Dynamics models to only pay attention to those models that you give credibility to because they were carefully constructed with your key purpose and goals in mind, and by people who have some level of understanding of the key variables and how they are related to each other.

All three Systems Thinking methods have both pros and cons. We explored a number of these in this study. Each of these methods is useful in certain contexts and situations. Although there are many nuances to consider that can benefit implementers, three stand out as factors that you definitely want to take into account when choosing a method. These are Scope Applicability, Clear or Ambiguous Action Steps, and Tangible or Intangible Results. (See Visual 17)

Comparison of Three Systems Thinking Methods



Visual 17

Scope Applicability refers to the degree of flexibility of the method to work for different levels of scope. Some methods apply for certain levels of scope (Vast, Medium, or Narrow) and not for others. Some cannot include different levels of scope in the same scenario. Some work really well in conjunction with other methods, while some don't.

Some methods have Clear Action Steps while others have much more Ambiguous Action Steps. The clearer the action steps, the easier it is to implement a method. On the other hand, jumping into the solution too fast can result in solving the wrong problem. This means that there can be some advantages to putting more

thinking into the front end of a problem, even if the action steps do not seem very clear at first.

There are some methods that produce Tangible Results more quickly than others that instead start out with producing only Intangible Results. Although the goal, for instance, of a company is ultimately to produce products--which are tangible results, it can be advantageous to focus on setting the stage for producing those products, rather than pre-maturely taking actions that may not produce profitable results.

Cognitive Thinking (for Systems Thinking) has a high level of Scope Applicability. It is useful for goals and projects that are very vast in scope, for those that are medium in scope and for those that are very narrow and task oriented. Even very narrowly defined scope type projects need to be aligned with corporate strategy. This means that taking into account the system as a whole is useful, even if it is not the most urgent factor for those workers who are producing the products.

At the other extreme, Cognitive Thinking makes it possible to consider very big projects, organizations, and goals that are vast in scope. The ITER project comes to mind which has the purpose of producing energy through nuclear fusion. This project spans a number of different countries, companies, functional tasks, and scientific disciplines and so it has a very vast scope. The beauty of Cognitive Thinking is that it also can combine different levels of scope into the same project.

Cognitive Thinking does not explicitly state what action steps need to be taken. This means that the implementers have to decide how to actualize this thinking process and incorporate it into their plans. A great suggestion, perhaps, if the implementers are stuck, is to use Derek Cabrera's DSRP method to get started. (Cabrera 2008) This methodology includes four key concepts: Distinctions (D), Systems (S), Relationships (R), and Perceptions (P). You will probably need to accompany it with some other techniques, but it can draw out some initial thoughts and get the ball rolling. The examples I referred to earlier, (See Visual 3 & Visual 4), did not incorporate DSRP specifically, so it's not a requirement.

Cognitive Thinking is mostly concerned with strategic goals and aspirations and therefore the key goals are usually concerning intangible results. These activities often include major organizational changes, like changes in the structure of the organization, or designing new mechanisms for collaboration, or refining performance evaluation systems and rewards and incentives, and setting up new training programs for employees.

However, Cognitive Thinking can also include for example, specifics regarding how a factory is being run, inventory policies, and programs to generate new innovation. How lower level activities relate to the operation of the system as a whole is very important, not just the overall organizational setup.

Design Thinking when applied as a process with the five steps has the most narrow scope of the three methods. It is usually used to come up with a new product, often a new product that is a new iteration of an existing product. Earlier GE Healthcare was mentioned because they produced a new cat scan designed for children. This did not involve any new technology, but did require some re-design to make it palatable for children. It has five steps, so the action steps are clear. Participants know what they are to do. In the end, their goal is to produce something tangible. If possible, the end result is to produce an actual physical prototype.

System Dynamics works best for a limited scope type of project. It might be a little bit less limited than Design Thinking, but it still it applies for a finite situation. Although there are a number of assumptions and decisions about what to include and how to include them in the model, still the action steps themselves are pretty clear once those decisions have been made. Perhaps, even a bit more clear than the action steps for Design Thinking. The results produced are closer to tangible, than intangible, but additional activities have to take place in order to actually implement the results produced by the System Dynamics model.

When determining which of these three methods will work best for you, first consider the scope of the project, and which of these best fit your situation. If it's very vast or includes a number of different levels of scope, Cognitive Thinking might be best. If it only concerns a rather narrow scope, then Design Thinking or System Dynamics might provide the best answers.

Also consider what kind of action steps you are able to take. If you need to take steps that you are not comfortable with, you may need to engage external support. If Cognitive Thinking or System Dynamics can provide the answers you need, then these tools might work best for you.

If you need to produce Tangible Results rather than Intangible Results, then you probably want to use Design Thinking or System Dynamics. However, if what you need is to come up with Intangible Results, then Cognitive Thinking will probably be the best approach.

To summarize, this study focused on three Systems Thinking methods, the pros and cons of each, and on identifying which contexts or situations that each method works best for. Finally, the background of the participants and the nature of the problem under consideration must also be considered.

Cognitive Thinking is a very flexible approach that can be applied to almost any situation no matter how big or small. While not the subject of this study, it's still important to note that the human mind is in some ways far superior to any type of AI, because of the numerous paths to success that we cannot yet fully fathom (how they are arrived at). Initially, I talked about (See Visual 1 & Visual 2) how the theory about these pathways has expanded. Even so, I don't think we have even begun to explain this. Our abilities cannot be fully defined or explained. Yet because of these abilities, we can use Systems Thinking for any level of scope, and we can combine them so that a number of levels are covered in our thinking process.

On the down side, it can be daunting for individuals with engrained functional thinking about a particular discipline, to be able to think differently. It may be necessary to invest in education and training before benefits from Systems Thinking can be realized.

Design Thinking works great for incremental innovation that addresses user concerns, when the right key experts can work together with commitment to produce a working prototype. The biggest problem is that it may not be able to take into account certain sets of data that might be very relevant. It's important to note that users do not always have the foresight to even be able to visualize what they really want in a product, so it doesn't always work.

System Dynamics can provide insight into complex systems when the goals are clear and the scope is well defined. Closed systems where the variables can be well defined are good situations for this method. Like Cognitive Thinking, System Dynamics is subject to the biases, assumptions and beliefs of the modeler. Also it can be deceiving because anyone can do it (with currently available software) and although it "looks" very scientific, and it may appear less subjective than other methods, it is subject to the same subjective failings.

People with incremental challenges who want to get to tangible results (like a new product) quickly, probably would use Design Thinking. Situations like how to maximize efficiency at a factory or track the progress of migratory birds would probably benefit from System Dynamics. Large organizations that are facing innovation challenges and trying to stay competitive would probably find Cognitive Thinking to be the best tool to insure their future.

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