Chapter

Interdisciplinary Integrated Tools to Problem Solving 2.0

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Abstract

Everyone understands the events they witness or read about according to their mental models, and that is one of the main reasons there are a lot of disagreements at workplaces and between friends and families. Considering this situation, plus the difficulty that most people face when trying to conceptualize problems, I suggest a course that includes series methodologies, working synergistically to deal with this problem that goes from understanding the differences between people to test multiple hypotheses and planning the solution implementation. Since 2014, I have been teaching with some colleagues this tool in the format of a short course that articulates systems thinking, mapping studies, information quality, and competing hypotheses. This course has been presented often not only in Argentina and also in Peru with great success. Considering the pandemic situation, since 2020, it has been taught virtually. The latest modification to the original structure of the course was the incorporation of the Gantt chart to design the implementation of the solution found. This paper will present our course and the logic behind it, its outcomes, and how it evolved with the different iterations.

Keywords: problem-solving, systemic thinking, information quality, decision making

1. Introduction

Being part of the information society and live in this time has a lot of advantages but pose a lot of challenges. The superabundance of information and the difficulties we face to evaluate its quality complicates our decision-making processes.

The COVID-19 pandemic has shown us clearly the impact of misinformation and how the constant influx of a lot of information -of which we know just little- affects our emotional and physical health and our understanding of reality and its evolution.

Since we are running like headless chickens most of the time after many objectives that become difficult to identify, when it comes the moment to think and conceptualize a problem, we need extra help to do it properly and get the expected result. This situation also affects how we look for information and based on which parameters we select it or not, how we validate our hypothesis, and how we plan what we need to do to implement the desired solution.

Here, I will describe the course and the different methodologies included in it and show how they articulate to give the students an easy way to understand and solve their problems.

2. Related research

There are several problem-solving methods, nevertheless, almost all of them follow this logic (**Figure 1**). But only a few of them include methodologies to implement the different steps in a structured and auditable way. Also, in most of the cases, the people involved in the problems are not considered as no not only as possible sources of solutions but as the ones who know the most about the situation and, at the end, the ones who will be involved in the change.

Methodologies as the TRIZ/USIT [2], Six Sigma [3], the VSM (Viable Systems Model) [4] and the many problem-solving in 4 steps or 6 steps that exists in the literature offer different tactics to approach the problems and find a solution [5]. Even when they are helpful in many specific fields, they are not do not look for a fluid tool, easy to implement in all possible problems as the one presented here.

The Six Step Problem Solving Model [6], developed at the University of Arkansas at Pine Bluff, is worth to highlight because of its characteristics and reasoning close to the one that laid behind I designed. This method includes for each step one or more tools and considers the participation of the people involved.

In closing, even though many problem-solving methodologies exist, the one presented in this paper could be consider as a combination of the best of others that exist with a twist of innovation.

3. The course

This problem-solving course entails integrating five methodologies: systems theory, mapping studies, data quality, and competing hypothesis, plus the Gantt chart. Together, they allow us to go from the problem conceptualization to the hypothesis testing and plan the solution in a methodologically consistent, unbiased, and structured way.

Using a combination of methodologies in an articulated way has its origin in a request made by the Peruvian Air Force. They wanted to have a dedicated course on research methodologies. After that, the course has been successfully presented in many places. Finally, the INAP (National Institute for the Public Administration, Argentina) requested an upgrade to include implementing the solution found, and the Gantt chart was included. So now the course goes from problem identification to solution implementation.

This course starts with a discussion about mental models and how their impact in the understanding of the reality. In this specific context, helps to realize why we all disagree about problems or circumstance and facilitate the communication and agreements [7].

Figure 1.
Problem-solving logic [1].

3.1 General systems theory

This problem-solving course starts with understanding the first out of the five methods that conform to this proposal, the systemic method, developed after the general systems theory. This tool is well known and widely used in many disciplines.

Ludwig Von Bertalanffy, the biologist who developed the general systems theory, recognized that his theory started to be developed back in Aristotle times when he said: "the whole is greater than the sum of its parts", describing the synergy, one of the core characteristics of the system when working [8].

Von Bertalanffy included the three premises that set the basis of the General Systems Theory in his book published in 1969 [9]. Those assumptions are:

1. Systems exist within systems;

2. The systems are open; and

3. The functions of a system depend on its structure.

Von Bertalanffy has described the systems' functioning considering the inputs, processes and components and output (**Figure 2**).

In the representation of how the systems work, it is implicit a time spam since the input enters into the system, then a process takes place, and finally the product of the process exits the system as output. Therefore, applying this method to understand a problem or situation provides us with a dynamic vision of reality, including its components.

One of the most intuitive examples of a system is the ecosystem. The word itself results from the merge of eco (house) and system. According to the Encyclopaedia Britannica, a definition of the term is: "Ecosystem, the complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space" [10].

A graphic representation of the ecosystem definition using systems theory could be (**Figure 3**):

The components of an ecosystem are related so a balance between them is achieved. This is another property of the systems, and it is called homeostasis.

Feedback is one of the essential properties of the systems and what means is that the system's output re-enters again as an input. This cyclic process is also linked with the homeostasis.

Let us analyze the feedback in other system, for example in a workplace where a modification is included. One role it will play will be informing if the changes have a positive or a negative impact.

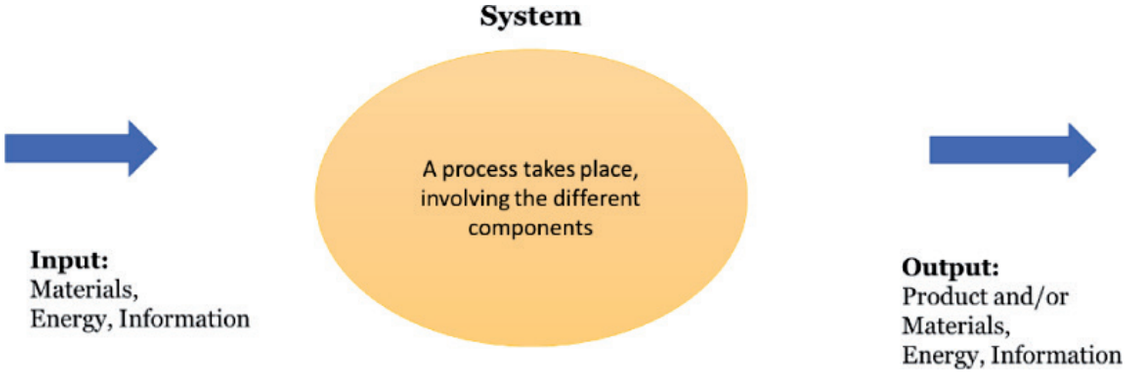

Figure 2.
How the system works (designed by the author).

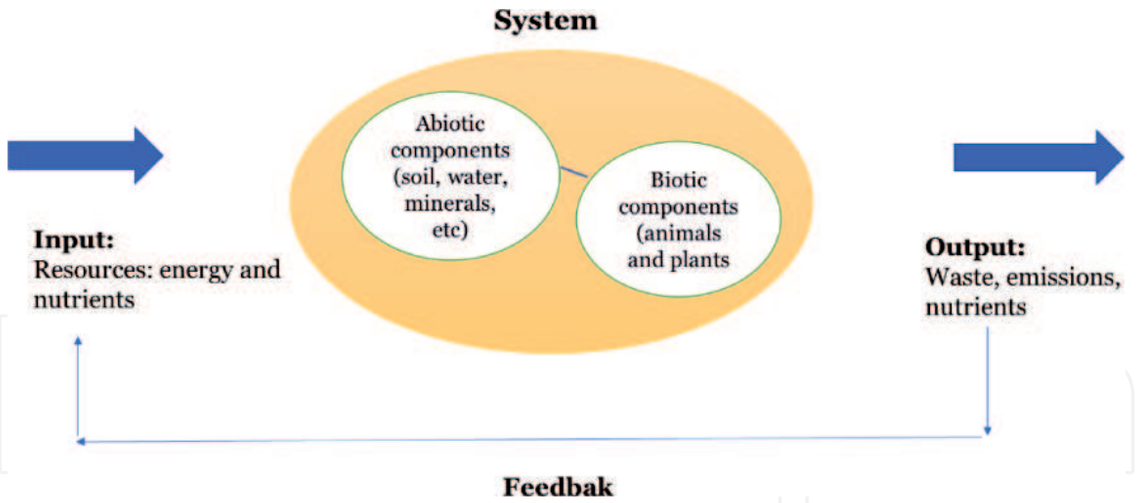

Figure 3.
Representation of an ecosystem using the systems theory (designed by the author).

The study of the systems has two possible approaches, one is the study of the system and its components and the processes that take place between them; and another is considering the border of the system, characterizing and studying what happens there. But in both cases the context is considered and the inputs and outputs (and feedback).

During the course, since this is the starting point, this method is used to conceptualize the problem and understand its components, the process, and its dynamic.

At this point, the students decide with which problem or situation they want to analyze and solve. By doing this, they move out from thinking to drafting and putting in words their ideas. This process takes time and requires reflection, and also decisions should be made to set up the limits (system border) and the components -and relations between them- of the problem under study.

When doing this conceptualization process, the system is developed with a specific objective and if the objective changes, the system will also do.

3.2 Structured searches

Once the problem is identified and described the look for answers and solutions start. At this point two possibilities exists: look for an existing solution or innovate if nothing has been done successfully by others. In both cases the search of the information in a structured way is optimal.

Considering the abundance of information, it is relevant to search on the internet following specific parameters and minimize the impact of our cognitive bias.

Systematic literature review or systematic mapping studies is the name of a methodology to execute searches in a structured way by following a detailed procedure.

The origins of this technique can be traced back to the problems the clinicians faced when relying in the available literature for their decision-making process. "In answer to this challenge, the worldwide Cochrane Collaboration was formed in 1992 to provide an expanding resource of updateable systematic reviews of randomized controlled trials (RCTs) relating to health care. Thus began the modern incarnation of the review article, a tool that had for many centuries been the mainstay for updating scientific knowledge" [11].

Later, this methodology was discovered and widely implemented by academics from the areas of systems engineering and informatics mostly to develop the state of the art of research topics. And later, considering its usefulness, it was adopted by other sciences and also used in projects design.

The author who is a reference for this methodology is Barbara Kitchencham [12] from Keele University. And Dr. Marcela Genero Bocco from the Alarcos Group (University of Castilla La Mancha -UCLM- Spain) is leading the field in Spanish-speaking countries [13].

This method is relevant in this problem-solving tool because it helps to minimize the impact of our cognitive bias when doing a search, particularly for selecting among the results. As humans, we have the tendency to tend to choose what agrees with our mental models or the concept or ideas we have in mind. Because of this, we may avoid reading relevant articles with a different perspective on the topic under study.

The methodology includes three phases: planning the review, executing it and writing the report.

In the first phase, many tasks will take place. First, the need for a review must be identified, particularly considering that applying this methodology takes time and effort and it is not for a simple quick search. By doing a review, it is possible to summarize all the information on a topic, in a format that resembles a database.

To begin with the practical steps of this tool, the research questions formulation is the next step. These research questions will be the tool to select the publications, considering whether they answer or not to them, and not how they do (this is important for the later analysis of the results). This way of selecting the publications helps to minimize the impact of our cognitive bias, allowing us to have the whole set of possible answers, and not only the ones we like.

Before performing the search, a protocol must be developed. This plan includes:

a. with what? Identification of the search terms, and also their synonyms and other alternative terms (the use OR and AND, or other Boolean operators is recommended);

b. where will the search be performed? The sources of information must be chosen and specified (use virtual libraries, Google or other search engines);

c. inclusion and exclusion criteria; and

d. a form to transfer the selected publications and the research questions must be designed, usually an Excel sheet.

In the second phase, the review takes place, and what was planned on the first phase here it is executed.

Once the search engine is selected, the terms are introduced, and the results appear. Now, it is important to check all the results, one by one, and the publications that answer the research questions will be transferred to the Excel file and the different fields will be completed. The inclusion and exclusion criteria will help to filter the results obtained, and finally the result will be a set of publications that fulfill the requirements and answer the research questions.

This methodology was designed to be implemented on virtual libraries. But it works perfectly in Google and other search engines like it.

After doing the search and filling the Excel, it will be possible to identify if an adjustment of the protocol is needed or not (new keywords, rephrase of the research questions, etc).

The publications database we will have as a result will include fields specific to each publication (author, date, publisher, title, etc.), and other relevant information, considered metadata, which will help perform a broader analysis.

The methodology concludes with the report writing. The text must include a detailed presentation of the protocol, an explanation of how the search was executed, and all the decisions made during the process to make the search repeatable and auditable.

The report will also include the analysis of the answers to the research questions, not only in writing but graphs could be performed considering the information will be included in an Excel.

This file will be the starting point to the execution of these methodologies, information quality (to evaluate the quality of the selected publications) and competing hypothesis (to identify the scenario with more support in the available literature).

3.3 Information quality core concepts

Having the possibility to access many sources of information when looking for something is fantastic. Still, the growing amount of data and information and the difficulties in knowing its quality created the need to develop a specific method to evaluate its properties [14].

Experts at the Massachusetts Institute of Technology (MIT) (Cambridge, Massachusetts, USA) developed an information quality method. Lately, professionals from other universities and countries expanded and added more elements to it.

The part of the method which will used in this problem-solving methodology is the one of categories and dimensions. The other two, that explore the role of the different stakeholders involved in the information management and the total data quality management (TDQM) cycle will not be considered here.

Wang and Strong [15], back in 1996 developed a framework to evaluate and hierarchically organize information. To create this method, they sent a survey to information consumers and master's in business administration (MBA) students asking about the most critical attributes that information should have. The result was a list of 179 attributes. After that, they performed a second survey to learn and understand the importance of the attributes identified. Finally, they come out with a list of 15 dimensions, grouped into four categories (see **Table 1**).

As the next step on the problem-solving methodology, the selected dimensions (not all are relevant in every circumstance) will be placed in Excel (from the structured search) as columns after the publication's details. A quantitative evaluation of each publication will be performed, getting at the end a value that entails the document's quality. Having these results will make it possible to rank the publications hierarchically.

3.4 Competing hypothesis

The competing hypothesis methodology was developed by Richards J. Heuer Jr., an intelligence analysis expert from the Central Intelligence Agency (CIA), during the Cold War, and a few years later was provided to the public [16].

This tool is especially useful in cases of complex problems, with many possible scenarios and a lot of evidence to analyze. It allows to study simultaneously all likely hypothesis and verify them with all the available information simultaneously. The outcome will be a table including the evidence and the hypotheses and the results of the evaluation performed (**Table 2**).

In this evaluation, the level correlation is showed:

(+) the evidence supports the hypothesis.

(++) the evidence highly supports the hypothesis.

(−) the evidence does not support the hypothesis.

(−-) the evidence does not support the hypothesis strongly.

Categories	Dimensions
Intrinsic	Accuracy, believability, objectivity, and reputation
Contextual	Value-added, relevancy, timeliness, completeness, and amount of data
Representational	Interpretability, ease of understanding, representational consistency and representation conciseness
Accessibility	Access and security

Table 1.
MIT information quality categories and dimensions (designed by the author, adapted from [15]).

	Hypothesis 1	Hypothesis 2
Evidence	+	+
Evidence	++	—
Evidence	+	Not apply
Evidence	Not apply	—
Evidence	—	+
Total	4+, 1- = 3+	2+, 3- = −1

Table 2.
Resulting table as consequence of the execution of the competing hypothesis method (designed by the author, adapted from [16]).

Not apply: there is no relation between the hypothesis and the evidence.

The winning hypothesis, in the **Table 2** example will be the hypotheses 1, is according to Heuer [16]: "The result of the methodology is which hypothesis has more support according to with the available evidence and not which is the hypothesis with a higher probability of occurrence."

This next to the last step will allow taking the publications selected in the structured searches after the quality evaluation and considering them as the evidence for this method. The hypotheses will be elaborated considering the objective of the systemic method along with the research questions.

This step will identify the winning hypothesis, which means the solution to the problem with more support in the available information.

3.5 Gantt chart

Now that the solution has been found, it is time to design its implementation. To do it, the Gantt chart will be used as method.

To design a Gantt chart, identify objectives and tasks for each implementation phase: design, planning, execution and evaluation.

The objectives preferable must be SMART, which means:

S: Specific, what do you want to achieve? Who needs to participate? When do you want to accomplish your objective? Why is it important?

M: measurable, how can the be progress measured? How do you know if the objective has been achieved?

A: Attainable or Achievable, can you achieve the objective? Do you have the skills needed to achieve the objective? If not, could you build them?

R: Relevant, why it is important? The impact?

T: Timely (or time-bound), when the objective must be accomplished? Is it possible?

George T. Doran coined the concept of SMART objectives, and he published them in the November 1981 issue of Management Review [17]. Since then, some authors added more letters to the acronym, and others created different ones. Still, the general concept remains the same: the objectives gain meaning when a task to be performed is associated to them.

In this final step of the problem-solving tool, the first step is to go back to the systemic method and use it as starting point. Over this scenario, the diagnosis will be performed, but also considering the winning hypotheses from the previous method applied. Considering this information, the specific objectives, and tasks (including the intended duration) must be identified. At this point, a qualitative evaluation is recommended. Asking the people involved in the project for their opinions and suggestions could bring relevant information to the objectives and tasks design for the whole project.

Next to the diagnosis, the planning of what needs to be done is the next stage. It is critical to carefully plan and link the objectives and tasks from this planning stage to the ones in the implementation or execution phase. One of the most common errors is to plan activities that have no correlation on the execution phase or design activities not planned in advance. And also, to put both phases in parallel, when they must be one after the other, sequentially.

Finally, the evaluation phase, it is time to measure if what was implemented has led to the desired scenario or to another. At this point, a qualitative evaluation is recommended.

4. Executing the tool

When we initiate the course discussing the mental models, the participants think about how they see the world and why we all have different opinions. Also, they usually increase their awareness about how bias they are because of their high engagement with the situation they are trying to improve.

It is like they experience Eureka moments.

After this, they can reduce the tension associated with the analysis of the situation and how they consider the other people. This is a first step that facilitates the following ones, when they apply the different methodologies to their problem.

Using the systemic thinking to conceptualize the situation or problem the participants are trying to solve is the next step. This stage is time and energy consuming since a lot of self-questioning and reflection upon not only the scenario but its components, relationships, inputs and outputs and understanding the objective of the system.

Often the participants think they have a problem, but after this phase of deep analysis, they discover sometimes that they were right and in others that it was not the case.

Forcing the participants to prepare the systemic method diagrams, helps them to visualize clearly the situation and they get ready for the next step, which is finding a solution.

Looking for answers and solutions in a structured way is what the participants to this course do when executing the mapping studies.

When performing this task, they complaint a lot because of the effort it takes, but later they realize how important is to have an Excel file that acts as database which condenses all the information.

The link between this method and the systemic thinking is given by the objective of the system which becomes the main research question in the structured search. Using this main question as cornerstone, the relevant aspects to it (and to find answers to the problem) can be easily identified.

Once the relevant publications are selected, its quality is measured using the information quality method. By doing this, since many options or potentials solutions are now identified, this evaluation could be a way to consider which of the available answers have better support.

Competing hypothesis method uses as evidences the publications obtained during the structured search, that also has been evaluated to measure their quality, and ranked. The hypotheses are related to both the objective of the systemic method and the research questions of the mapping. The winning hypotheses, since sets of hypotheses linked to the different aspects of the problem are expected, will be the ones considered to design the implementation plan using the Gantt chart.

The different phases of the Gantt chart, diagnosis, planning, execution and evaluation are developed following the objective of the system (3.1), as guidance, and using winning hypotheses (3.4) as clues to internally organize what must be done to solve the components or aspects of the main problem.

Using this tool, participant to the course solved and implemented problems related to the administrative functioning of a workplace; design new regulations; design and implement customer care systems, etc.

5. Conclusions

This problem-solving course has been presented in different formats over a dozen times, always successfully. A previous publication summarizes the accomplishments until 2016 [18], which were largely surpassed with the new editions of the course and the new venues where it was taught.

Considering the audience and their specific needs, the focus on the different methodologies changes. Usually, the most demanding stage is the implementation of the systemic method in order to conceptualize the problem and also the Gantt design.

The problems that were considered during the courses range from improving to make significant changes. Often, the students implemented what they design during the course, and the results were the ones expected. The effectiveness of this method is proved.

The methodologies included led to finding the solution to many problems, in an unbiased, structured, auditable and at the same time, simple way.

Finally, I consider there is still room for improvements, and maybe shortly more methods or resources will be added to have a more usable and easier to implement tool. Those that are under evaluation are the formal incorporation at the beginning of the curse of an introduction to different decision-making models so the participants would have more information to be applied not only during the problem conceptualisation phase but also to use them at the time of communicating and implemented the solutions. Other resource under evaluation to be added after the Gantt chart is the elaboration of dashboards, which will be useful to monitor the different processes under implementation.

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