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Procedure to Obtain and Organise Creative Solutions. Water Shortage Case

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Abstract. In this paper, a general problem is understood as one affecting many people and with a complex solution, for example water shortage. This paper presents the problem of limited water resources in a housing development located in an “average” climate zone in Spain (specific problem), and water shortage is the general problem. The procedure here proposed begins by abstracting a specific problem to a general problem. Several independent solutions are listed and analyzed by confronting them with conditions of place, time and circumstances defined in the specific problem in order to prioritise possible solutions. Imaginative solutions can also be provided to investigate new areas of solution. Once a solution is chosen, the process is repeated twice to find sub-solutions and sub-sub-solutions, respectively, the latter being more technically concrete. This process is especially appropriate to initial conceptual phase of engineering design, when creativity is needed.

Keywords: general problem, lists of solutions, stage analysis, water shortage.

1 Introduction

In this paper, a general problem is roughly defined as one affecting a large number of people and comprising various sub-problems, and therefore having many possible solutions. The example of general problem given here is water scarcity, and the specific problem is water shortage for a housing located in Spain (see section 3). Water shortage is the result of increasing water demand associated with population growth and increased level of development. The “average” rain in Spain is 642 l/m^2-year (Capel, 2010).

Several factors are involved in the solution of a general problem, making it necessary to consider their interactions and connections with other problems. That is, the problem is usually a complex one. The best solution to a general problem is often made up of various partial, solutions suitable for certain places, times and circumstances. The combination of these allows a general complex problem to be solved.

The challenge of coming up with new ideas of solution can be met by direct use of a person’s creative faculties and imagination or application of a specific methodology to aid creativity. Individual production of ideas can also be complemented and enhanced by teamwork.

2 Inventive Problems

Inventive problems are those whose solution requires new ideas. The sum of contributions of multiple minds generally generates more and better ideas than an individual mind. Nevertheless, some quality ideas have been thought of by one single mind, but based on previous work conducted by other minds. If the sum of contributions of multiple minds is structured by a methodology of creativity, the result is considerably improved. Obviously, the quality of the participant minds may also have a strong influence the output.

Great minds furnished with up-to-date knowledge can be consulted, if desired, using the Delphi technique (Sackman, 1974), which allows connecting people by information and communication technologies (ICT) in an asynchronous way, overcoming physical barriers and following a resolution and interaction protocol. The TRIZ technique (Altshuller, 1990) is also useful as it summarises all historical inventive procedures based on the best-patented inventions. The combination of the above items, namely brilliant minds with up-to-date knowledge and using creativity techniques could provide excellent results.

Inventive problem solving varies with problem complexity. The resolution of general complex problems, like water scarcity, involves several human and material resources, as well as varied knowledge, whereas in the case of a simple or more specific inventive problem, e.g. the design of a tap water-saving device, less knowledge is required. As is obvious, there are many levels of complexity between these extremes.

The approach from specific to general problems has the advantage of providing a global view of difficulties and factors affecting them. The analysis of these elements allows actions suitable for a certain time and place to be prioritised more effectively than when specific or partial solutions are the starting point since, in this case, the broad view of the problem is missing. Nevertheless, this process of abstraction to general problems is more time-consuming and requires greater knowledge.

3 Description of a Process to Solve Specific Problems

An effective tool to structure the resolution of general and particularly complex problems is the "Mind Maps" (MM) technique (Buzan, 2000), on which the process below is inspired.

In this case MM will be used only to draw up an initial list of different solutions independent of each other, without looking for sub-solutions.

Given a specific problem for a certain time and place that is of complex resolution, the latent general problem behind the former is abstracted (figure 1). For example, the specific problem of water shortage in a detached house located in an "average" climate zone in Spain is abstracted to the general problem of water scarcity.

Once the general problem is formulated, a list of different and independent solutions (represented by first range of blue arrows) defining a first level of solutions is created. Preferably this list is graphically depicted as a MM (Lloveras et Al., 2009). No sub-solutions are subsequently obtained, but rather this first set of solutions is analyzed and confronted with the specific problem in order to choose the most appropriate one.

The process is repeated in such a way that, from the selected solution, a new list of sub-solutions is drawn up and analysed to finally choose one sub-solution, and so on. In this way, the final solution (sub-sub-sub-solution) or solutions that could be the optimal ones to solve the specific problem in a certain place, time and circumstances take shape.

The method of obtaining solutions at each stage can be varied, and results can range from low to high quality. One possible best performance is this generation of solutions is by consulting specialists over the world, and if in addition these specialist use the TRIZ methodology.

Time can be allowed between listings of derived solutions to gather information and reflect on and incubate ideas for solutions (latency period).

This process differs from MM in that solutions are analysed in each stage while in MM they are provided at a global level.

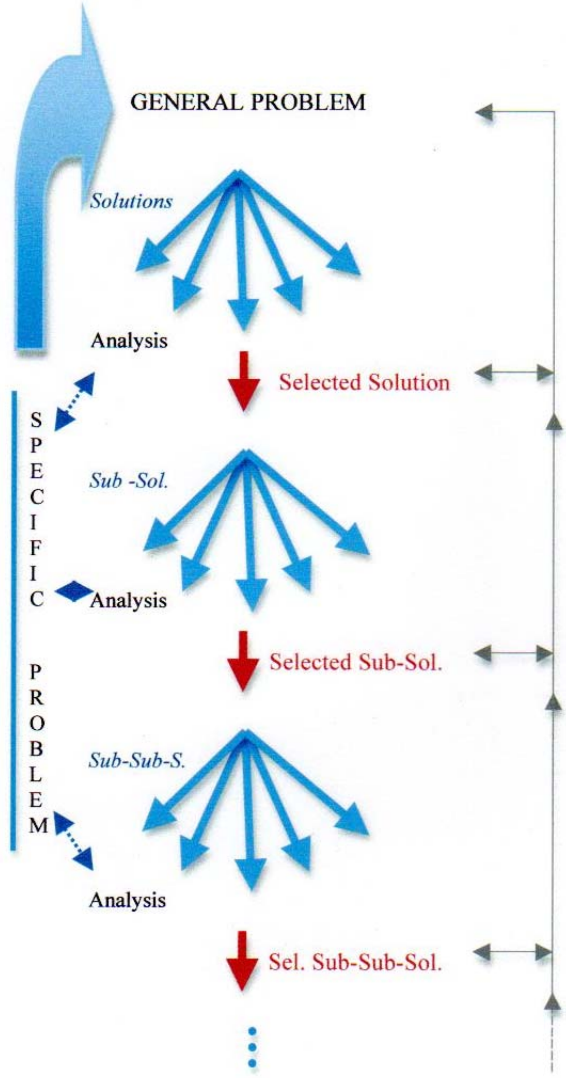

Fig. 1. Process of specific problem resolution through general problem and deployement of solutions lists.

3.1 Example of a process to solve general problems

The example problem chosen is water shortage for a housing development located in an "average" climate zone in Spain. This problem is then abstracted to the general problem of water scarcity.

The analysis of the general problem gives us a full view of various aspects and solutions to be considered.

Thus, the global view based on a specific problem requires the knowledge of many aspects of the problem, as well as its possible solutions.

A list of independent elementary solutions of the general problem of fresh water scarcity is given below (in this example, the graphics like MM are not used). It should be noted that all current technical possibilities must be studied.

- water-saving systems currently available;
- gray or dirty water purification/drinking water treatment;
- use of rainwater;
- desalination of marine and brackish water;
- water transfer from water-surplus sites;
- water extraction from air;
- virtual water supplied through products from water-surplus sites;
- water extraction from groundwater (wells);
- snow and glacier melting;
- water obtained by chemical reactions or synthesis;
- …

As said before, the general solution implies coming up with several partial solutions. For a specific problem, the specific solution is that which best fits a particular place, time and circumstance.

Going back to the example, the solutions must be explored to find an optimal one. Thus, after studying all possible solutions, they are prioritised those what are the better suited to the specific problem. Let us suppose that the use of rainwater is the first in the list.

At this point, the other solutions are discarded and a new list of possible solutions associated with the use of rainwater (sub-solutions) is drawn up.

There now follows a non-exhaustive list of sub-solutions for the use of (surface) rainwater collected in a place or its immediate surroundings:

- rivers;
- torrents;
- irrigation ditches;
- lakes;
- rainwater collection systems;
- rainwater storage tanks;
- water collection from buildings, streets, gardens...;
- low cloud condensation or humidity extraction;
- where possible, snow storage in cold months;
- artificial rain production;
- ...

The sub-solutions in the above list are analysed and prioritised, but no sub-sub-solutions are searched for. Let us suppose that water collection in buildings and constructions in general is selected.

Increased technical concretion is achieved with the next list of alternatives to the solution of water collection from buildings, streets, and gardens, among others, i.e. the third one.

Water collection from:

- roofs;
- flat roofs;
- terraces;
- yards;
- canvases or big tops for auxiliary constructions;
- streets and squares;
- gardens;
- rainwater storage tanks which control the flow collected from streets;
- ...

One or more suitable solutions for the problem can arise from the study of these sub-sub-solutions and the balance between water needs and possible water supply, costs, etc. Two concrete possible solutions for this level are explained below.

One possible solution is, for example, to direct the rainwater flow collected from streets into storage tanks where it can be sized to match its subsequent use, for example irrigation of trees, gardens or orchards in the housing development. In this case, strategically positioned storage tanks would be a nearby, decentralized water supply system for irrigation. It is worth noting that this method requires an infrastructure for water channelling to be built.

Another solution would be the direct use of rainwater in houses with a roof or a terrace. It would then be necessary to analyse water needs and rainwater collection for every house.

For example, if average annual rainfall in the case area is about 642 litres per square meter (average in Spain), and the surface for water collection in the house is 120 m^2, the amount of rainwater collected by end of the year would be 77.040 litres. If the daily water consumption per person is approximately 140 litres, each person consumes 51.100 litres annually. Thus, the amount of water collected would be sufficient to meet the water requirements of one people.

During the dry season in 2008, daily water consumption per person in Barcelona dropped to about 110 litres (40,150 litres per year), one of the lowest rates of all European cities. A domestic recycling or water purification system could easily reduce daily consumption per person to about 70 l (25,500 l / person/ year). This way, the amount of rainwater collected on this surface of 120 m^2 would be enough to meet the water needs of 3 people. Larger collection surfaces or daily lower consumption rates per person resulting from increased recycling of gray or black waters will allow greater self-sufficiency

As for irrigation of the development vegetation, a method for collecting rainwater from streets, squares and gardens in storage tanks and a distribution canal system would be required.

The proposed solutions could coexist with the current water distribution system, opening a wide field for technological innovations that, despite involving considerable financial investment for municipalities and individuals, would also create job opportunities as monitoring and system maintenance staff would be necessary.

The rainwater collection solution would be advantageous over the current philosophy, namely to supply water by distribution systems, since collecting rainwater is certainly more sustainable than treating and bringing water sometimes from distant places.

This chain of lists of solutions is used to organise the solutions of similar level, which results in convergence towards an optimal solution for a specific case. Moreover, these listings have the advantage that they can be revisited if reviewing the solution or finding a better one were required.

3.2 Lists of imaginative solutions

The series of lists of solutions can contain solutions technically beyond those known to the state of the art. Ideal imaginative solutions could be added at each level or stage of solution even if they use new, unknown or even magical technologies.

Thus, the exercise of imagination allows going beyond reality, sometimes opening new areas of research that might lead to the future development of new technologies (Lloveras, 2009).

Figure 2 shows imaginative solutions at each stage or list of solutions. In this case, new imaginative ideas are added to each list of solutions. The analysis of lists thus extended can provide new solutions or probably new ways of exploration or investigation. For example: artificial trees that capture rainwater and solar energy, or extraction of water stored in microbial creatures that capture the air humidity.

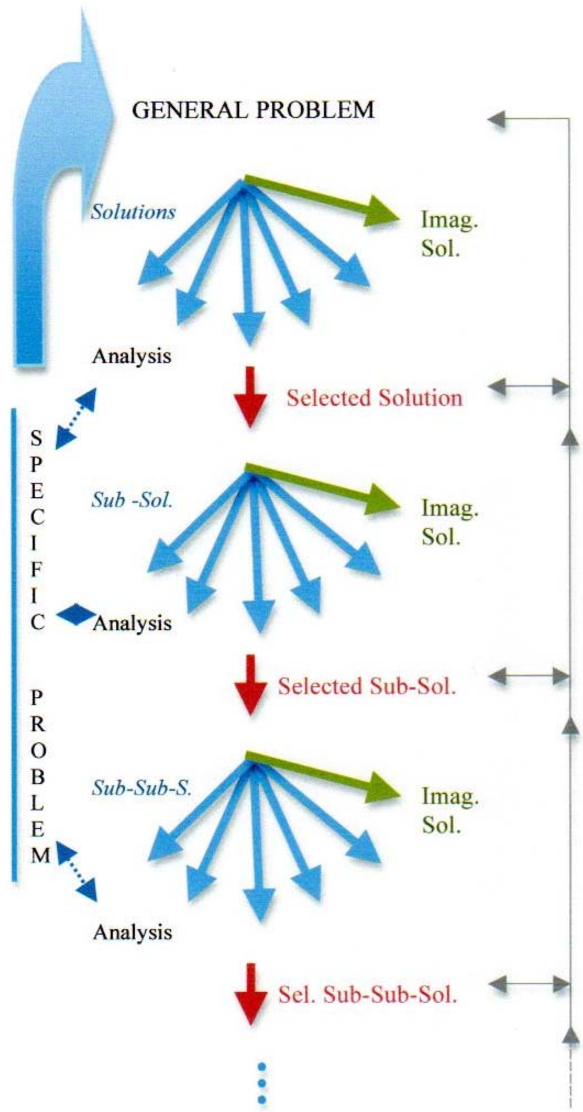

Fig. 2. Process for structuring solutions to a specific problem in which imaginative solutions are added to each list of solutions.

4 Conclusions

A specific problem is the starting point of a process in which the general problem is abstracted. Then, several primary technical solutions for the case in study are listed, without including sub-solutions of each solution. These primary solutions are analysed and one is selected, becoming the origin of a new list of sub-solutions. The process is thus repeated several times, descending into ever more specific and optimal solutions for the case.

This procedure takes a holistic view for the general problem, but also for solution, sub-solution, sub-sub-solution, etc. and is drawn in ordered lists of solutions at every stage. This cascade of solutions is increasingly more concrete and gives a frame of requirements for technical solution.

Also this procedure has the advantage that all proposed solutions are explored but at any moment it is possible to go back to other solutions if necessary.

If the lists are generated, for example, by the best specialists in the field working together asynchronously by means of ICTs (e.g. the Delphi protocol) and also use TRIZ, the results could be excellent.

The introduction of imaginative or ideal solutions at every stage of the lists may greatly enhance the range of solutions while opening ways of exploring new ones.

The practical case of water scarcity in a housing development in an average climate area in Spain shows the possibility of using rainwater effectively. This practice, with which self-sufficiency can be achieved in certain cases, has been used throughout history but has been lost to a great extent in the last century. Nowadays this self-sufficiency might be technically possible, even with a smaller area to capture rainwater, in this case it is necessary the use of techniques to save water and water recycling systems.

The proposed procedure for finding the solution of a specific problem applied to a specific place, time and circumstances can be generalised to other specific problems.

This process is especially appropriate to initial conceptual phase of design that needs creativity, but it can be extended to other phases of design.

In the future, several general problems could be systematically developed in its early stages of solutions and then implemented in digital databases for general use. Then, this procedure could be very easy to apply to a specific problem with developed general problem. But always will be possible to find new and creative solutions.

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