IPG as a New Method to Improve the Agility of the Initial Analysis of the Inventive Design

Masih Hanifi
University of Strasbourg
4 Rue Blaise Pascal, 67081 Strasbourg
France

Hicham Chibane
INSA Strasbourg
Boulevard de la Victoire, 67000 Strasbourg
France

Rémy Houssin
University of Strasbourg
4 Rue Blaise Pascal, 67081 Strasbourg
France

Denis Cavallucci
INSA Strasbourg
Boulevard de la Victoire, 67000 Strasbourg
France

TRIZ method has long proven its value without appearing to the industrial world as inevitable. Design researchers have therefore addressed the limitations of the TRIZ method and have overcome them with more systematic approaches. Among these, the Inventive Design Method (IDM) has been the subject of several articles and put into practice in the industry. It is considered an improvement over TRIZ but still suffers from some drawbacks in terms of the time-consuming nature of its implementation.
We focused on the IDM process by trying to both identify its areas of inefficiencies while attempting to preserve the quality of its deliverables.
Our approach consists of applying the precepts of Lean to IDM. The result is the Inverse Problem Graph (IPG) method, inspired by IDM, but offering significant progress in reducing the time required to mobilize experts while preserving its inventive outcomes. This article outlines our approach for the construction of this new method.

Keywords: *Inventive design, Systematic innovation process, TRIZ, Complex problem, Lean theory, Root contradiction analysis, Root causes analysis, Initial analysis.*

1. INTRODUCTION

In recent decades, many companies have been competing on improving innovation cycle time because of its importance to their success [1][2]. There are many examples in today’s competitive world that highlight the importance of time in innovation. Among them, we can mention the recent emergence of the coronavirus case, called COVID-19, whose rapid international and national spread caused a global health emergency [3]. Indeed, in this case, pharmaceutical companies show that they do not have an adequate speed to respond to the world’s urgent need.We can also mentionthe time-consuming bio-inspired design projects such as the innovative design of knee protectors[4], development of miniature robots [5], or commercial aircraft performance improvement [6]. The designers in these types of projectscould overcome this drawback by adopting systematic approaches such as TRIZ.

GenrichAltshuler developed TRIZ or Theory of Inventive Problem. This approach states that any problems encountered by designers in their projects have probably also been dealt with by other designers [7]. TRIZ could contribute to reducing the amount of time needed to reveal an optimal solution and launch a new product [8]. However, the application of the classical TRIZ method in the R&D departments has several limitations [9]. The first is that it does not provide any methods to formulate the problems in the initial situations. Secondly, TRIZ does not offer any means to lead its users to select the best solutions among those proposed. As a third limitation, TRIZ does not also provide an accurate way of revealing a contradiction. Finally, there is no complete description of its components and the relationship between them in TRIZ’s body of knowledge. To overcome these limitations, researchers have developed numerous frameworks, among which the Inventive Design Methodology (IDM) can be mentioned.

1.1 IDM’s Drawbacks and the Proposal to solve them

IDM is a framework that has been developed to solve the limitations of TRIZ and to complement its body of knowledge with other theories such as Pugh’s theory or graph theory [10]. This framework consists of the following phases [11,12]:

1. Initial Analysis phase: In this phase, at the outset, the designers should gather all the relevant knowledge from internal documents and patents, tacit expert’s know-how, and other documents related to the subject. Then, the accumulated knowledge should be transformed into a graphical model to facilitate decision-making [10]. For this purpose, it is possible to apply the methods such as Problem Graph, Network of Problem (NoP), and Root Conflict Analysis (RCA+).
2. Contradictions Formulation phase: In this phase, the designers could apply several methods to formulate the contradictions, which are technical and physical issues in a system [9,13].
3. Solution Concept Synthesis phase: In the third phase, the designer applies different TRIZ tools to solve physical and technical contradictions [14,15].

Received: May 2021, Accepted: June 2021
Correspondence to: Masih Hanifi, PhD student,
University of Strasbourg, 4 Rue Blaise Pascal, 67081 Strasbourg, France
E-mail: masih.hanifi@insa-strasbourg.fr
doi:10.5937/fme2103549H

4. Solution Concept Selection phase: In the last phase, the experts should weigh the concepts in order to measure the impact of each concept. To this end, they could apply an evaluation grid to select the most relevant concept [10].

Nevertheless, one of the criticisms often leveled is that this approach does not have the necessary agility, and it is time-consuming [16-18]. This is mainly due to the implicit research in each study to construct a complete map of a problem situation by interviewing experts involved in the study and extracting all their knowledge, regardless of how effective it is in solving the problem. This stage leads to lots of contradictions that only some of which are used in the final phase to obtain the solution [19]. Therefore, it was necessary to combine IDM with other methodologies that give its process the characteristics of an agile methodology, including the capacity for iterative development and the capability to generate a rapid and flexible response to change [20]. One such methodology is the Lean method.

The origin of the lean theory can be found in the practices of the Toyota Motor Corporation in the 1950s [21]. Nevertheless, its introduction into the world of business was through books such as [22] and [23]. These books focused on the manufacturing aspect of the business. However, their authors emphasized on the implementation of the same principles in other indus–trial sectors, such as innovation, in order to eliminate non-value-adding activities within a process to achieve excellence [24]. Hence, in [19], the authors applied Lean principles to IDM.

The authors in [19] did not go into the details of an operational functioning method. Therefore, in this article, we show how to apply these Lean principles to optimize IDM. This article displays this application, and aims to increase the agility and efficiency of the initial analysis phase of IDM. To do so, we were inspired by the third and the fourth principles of Lean, which suggest identifying possible solutions to create a flow and a pull stream of information between the stages of the process, to develop our proposal to formulate the problem situation in the initial analysis phase of IDM.

The rest of the paper is organized as follows. In Sect. 2, we present the relevant literature review. Subsequently, Section 3 displays the structure of the proposed method and its steps. In Sect. 4, a case study is presented in which the proposed method is applied to introduce a new way of observing the COVID-19 situation in order to formulate the related problems and to suggest relevant candidates of solutions, proposed by other medical specialists, by applying TRIZ tools. In Section 5, we make a comparison between our method and other techniques with the ability to formulate the problems. Then, Section 6 presents the discussion, and reports the conclusion and suggestions for future work.

2. OVERVIEW OF ACTUAL STATE OF THE ART

2.1 Initial Situation Analysis methods

As we mentioned previously, initial analysis is a phase that involves gathering all the group's knowledge to construct a map of the problem by applying a variety of methods. In the state-of-the-art, we identified two groups: 1) Cause-searching-based methods, and 2) Effect-searching-based methods.

2.2 First group: Cause-searching-based methods

The existing methods in the first group are applied to identify the causes related to the selected problem in a system. These methods are attached to the following sub-groups: 1) Non-illustrator of contradictions. 2) Illustrator of contradictions.

The first sub-group comprises the methods such as Cause-Effect Chain Analysis and Ishikawa [25][26]. These methods cannot reveal the contradictions. For this reason, the designers, particularly those looking for innovative solutions, require the methods in the second sub-group.

The second sub-group is related to those methods with the ability to represent the contradictions. These include Root Conflict Analysis Plus and Cause-Effect Chain Analysis Plus, described in below. In inventive design, we need to overcome the contradiction in a complex problem. Hence, we focus on this category.

Root Conflict Analysis Plus (RCA+) could eliminate the difficulties of extracting contradictions [27]. Its process begins with the vague statement of a problem, located on top of the diagram. RCA+ uses several rules to parse this vague statement [28]. Unlike classical RCA, the designers do not use the why-question, which could also show the objectives, to identify the causes. Instead, they apply the question "What is the cause?", showing the object, its feature, the physical parameter related to an object, and the action which is responsible for producing the problem [27]. The resulting cause, in response to the "what" question, could have a negative effect, and so on. If the identified cause leads to a positive effect, along with its negative effect, it is known as a contradiction in the RCA+ diagram. Once the identified cause has only a negative effect, the chain of the cause will be explored downward until appearing a contradiction [27]. A cause could be written as a sentence, presenting the condition of a parameter of a system, a description of a function, and a radical change of system [27]. In the structure of RCA+, we can find four types of causes: 1) A cause with a negative effect, which should be eliminated. 2) A cause with a positive effect, which does not need to be changed. 3) A cause with a positive-negative effect, which shows the contra-diction in the system. 4) An unchangeable cause [27, 28]. After completing the first chain, the designers continue the process for other problems with a negative effect in the diagram until discovering all potential causes. A designer stops the development of a chain of causes in the following situations: 1) an unchangeable cause, which could not be changed for the reason like laws of nature, weather conditions, local and internati-onal policies, legal obligations. 2) A cause with a positive and negative effect, showing the contradiction. 3) A cause beyond control [27,28]. Figure 1 shows an RCA+ related to a project. The RCA+, showing the contradictions, could play an important role in presen-ting a problematic situation. This method could also provide direct input for the contradiction resolution techniques in the next phases of inventive design [27]. Nevertheless, a designer should create all chains of causes in the initial analysis phase, without paying attention to their utility in the solution stage. Additionally, this method does not merge the solution directions into its main structure. This is why a method such as Cause-Effect Chain Analysis Plus has been suggested.

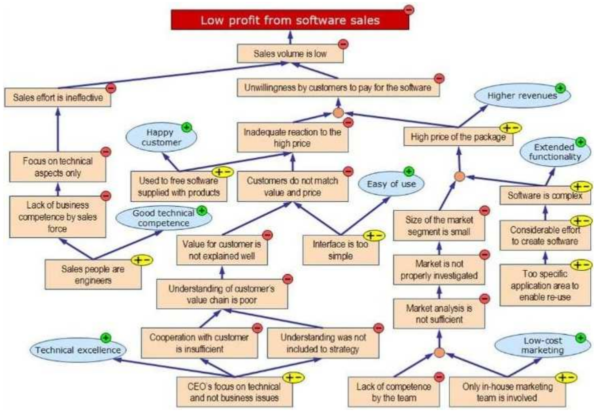


Figure 1. A project which applied Root Conflict Analysis(RCA+) to formulate the problem [29]

Lee et al. introduced the Cause-Effect Chain Analysis Plus (CECA+) method. This method has a development trend quite similar to RCA+ [30]. Figure 2 shows part of a CECA+ diagram. Although this method could demonstrate the contradictions, it ignores the waste of time in formulating useless chains of causes. Furthermore, this method could not show solutions that could partially solve the problems. The reviewed methods in the second group could solve the last drawback by adding partial solutions to their structures.

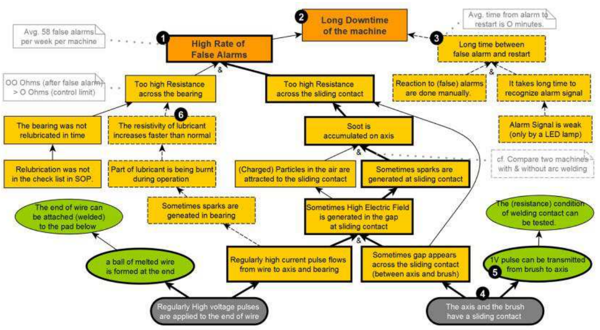


Figure 2. Part of a Cause-Effect Chain Analysis Plus carried out for a project [30]

2.3 Second group: Effect-searching-based methods

The second group is related to those techniques and methods used to investigate the effects of initial problems. In this group, we could find the Network of Problems (NoP) and Problem Graph.

NoP has been developed in the OTSM-TRIZ framework theory to help designers to break down an overall problem into a set of sub-problems, which are easier to solve [31,32]. A NoP organizes related knowledge to the problem situation and could help to solve a contradiction [31]. However, its original version did not provide a clear definition of the nodes, which constitute its main structure [31]. Additionally, due to the method guide, designers should start projects with a complex problem, being overly general, which causes an excessive expansion of the network of problems and designer's confusion. For solving some of the drawbacks related to NoP, researchers proposed other methods, one of which is the problem graph method.

The problem graph method has been introduced in the framework of Inventive Design Methodology [33]. This method demonstrates a connection between a large set of problems and partial solutions, resulting from a problem situation. According to the definitions presented for the components of the problem graph structure, a problem is a sentence that describes an obstacle, barricading the achievement of objectives [11,33]. A set of interrelated problems, sufficient to describe the main problem situation, is defined as the problem space [17]. Considering the same definition provided for the structure, a partial solution explains the knowledge of the members of the design team about a patent or upon their experiences [11,33]. A set of partial solutions related to problem space forms partial solution space [17]. As shown in Figure 3, a problem graph can graphically represent a problematic situation. Furthermore, it presents a formal definition of its main components, constructs its structure. However, to create a problem graph, it is necessary to dedicate a lot of time collecting information at the beginning regardless of its usability at the end of the project.

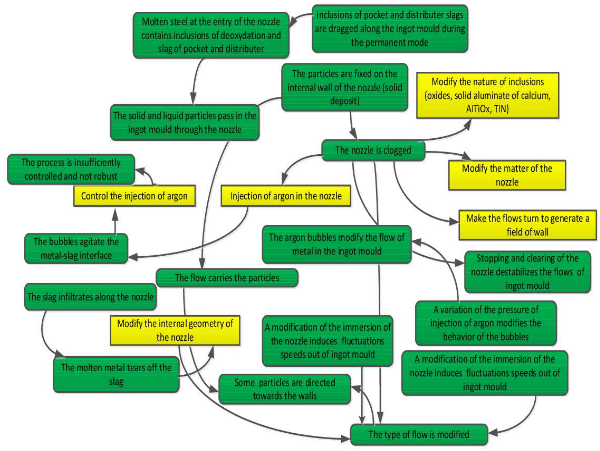


Figure 3. Problem Graph Application for formulating problems [33]

As we have seen, most of the analyzed methods in the literature review do not take into account the time spent gathering the group's knowledge, which is sometimes useless to map a problem situation. As a result, it was necessary to apply complementary approaches such as Lean to improve the agility and performance of the method.

2.4 Lean Theory

Lean theory was introduced into the business world through the books [22] and [23]. The authors of these books emphasized that Lean principles could be implemented not only in the manufacturing aspect of the business but also in different industrial sectors to eliminate various types of waste within these sectors [21] . This theory has classified seven forms of waste as follows: 1) Generating more than required. 2) Products or information that could not meet the expectation. 3) Unnecessary raw material, work in process, finished stock storage, and delay of products or information. 4) Unnecessary process steps. 5) Movement of information and products with no added value. 6) Waiting time for information, people, or products. 7) Poor workplace structure , causing a loss of items [34][35]. Lean proposes a set of principles and techniques to continuously remove different waste during the process to increase its efficiency and agility. Nevertheless, to eliminate waste and deliver improvement beyond the boundaries of manufacturing, it is necessary to understand five Lean principles. These principles are as follows [36]:

1. Value definition: it implies that it is necessary to get rid of activities that use resources but cannot create value.
2. Value-stream specification: it is essential to highlight non-value added activities within a process.
3. Making a value-stream flow: the process should be optimized in order to obtain a flow of information and raw material.
4. Producing while taking requirements into consideration: it is essential to produce by considering the requirements.
5. Monitoring for waste products regularly: Waste removal must be constant.

2.5 Application of the Lean principles into IDM

In this article, the Lean principles, particularly the third and the fourth one, encouraged us to develop a method for the initial analysis phase that gives the characteristics of agile methodologies, such as iterative and evolutionary development, to IDM. For this pur–pose, we firstly analyzed the result of the research of [19], in which the authors highlighted the Value Added, Non-Value Added activities related to the phases of the IDM framework, to understand the drawbacks of each phase. The authors in their analysis showed that desig–ners should collect and analyze all the data and partial solutions without paying attention to their use in the solution step. In the contradiction formulation phase, they also looked at the same problem that designers for–mulate, all the contradictions that are sometimes use–less. Their analysis also demonstrates that designers use only some of the collected problems, partial solu–tions, and the formulated contradictions in the solution phase.

The third and fourth principle of Lean suggests to optimize the process by creating a flow and a pull stream of information between the phases of the process. Accordingly, we considered that it is essential to start the process of inventive design from a problem that could connect the designers to the most appropriate solution. Hence, we realized that if the designers formulated the problems from the lower-level of a problem situation instead of the upper-level, they could avoid collecting many useless problems and partial solutions. Accordingly, by integrating the best features of the methods with the ability to illustrate the contradictions, we suggested a new method, which extends the chains of problems and partial solutions in the opposite direction of the analyzed methods. In the next section, we will introduce this method.

3. PROPOSED METHOD: INVERSE PROBLEM GRAPH (IPG)

3.1 Notions of the IPG components

The Inverse Problems Graph (IPG) includes the follo–wing types of entities, shown graphically in Figure 4:

1. Problem: In IPG, a problem is a sentence that represents a barrier, preventing the fulfillment of what has to be done [37]. The construction of this sentence could be as such:
   - Subject + Verb + additional information, describing the situation.
2. We proposed five types of problems for the structure of IPG, as Figure 4 illustrates:
   a) Initial problem: It is a problem at the first level of the graph. This problem is defined according to the objective of the project.
   b) Harmful problem: It is a problem that has a harmful effect on the system, removed from the system by eliminating the contradiction [30][38]. This problem causes the initial problem or another harmful problem. In the event of such a problem, it is essential to pursue the chain of causes to reach a harmful-useful problem.
   c) Harmful-Useful problem: This is a problem that is both harmful and useful to the system. If a problem contains such ambiguous aspects, both seemingly beneficial and harmful for the system, this signifies that the problem should be reformulated as a Partial solution to become the center of a contradiction[30][38].
   d) Source of a partial solution: It is a problem that causes the partial solution. This problem is located at the end of the contradiction.
   e) Out-of-capacity problem: There are some problems that are harmful, but the designer does not have the ability to eliminate them.
3. We adopt the partial solution proposed by[37]: A phrase that expresses the knowledge of the members of the design team about a registered patent or their experience. The structure of this phrase could be as follows:
   - Infinitive + additional information describing the situation
4. We also use the parameters or notions proposed in [39]: the classification of the existing parameters in IPG's structure is as follows:
   a) Evaluation parameters: These are the parameters that give the designers the capacity to evaluate their design choice. In IPG, a problem gives rise to evaluation parameters.
   b) Action parameters: They are parameters whose nature lies in the capacity of state modification. Each partial solution in IPG could result in this kind of parameters.
5. Level: The level specifies the location of the problem and partial solution in the IPG hierarchy, by considering that the direction of movement in the graph is from left to right or from initial problem to

right. As Figure 4 shows, there are three types of levels as these include:

a) Effect-Level: The level that is before the selected level in the graph.
b) Cause-Level: The level that is after the selected level in the graph.
c) Selected-Level: The current level of problem analysis.

6. Iteration: The number of entries in the IPG, to choose a contradiction, is called iteration. In Figures 5 and 6, you can see the Lean-Agile IDM framework (LA-IDM) with IPG (Figure 5) and the Inventive Design Methodology (IDM) with other discussed methods in the literature review (Figure 6). The Lean theory and its integration into the IDM framework led us to add this notion to IPG's structure, and we proposed a new framework for inventive design, called Lean-Agile Inventive Design Framework. In the following, we introduce the steps of IPG, which belong to the first phase of the LA-IDM framework.

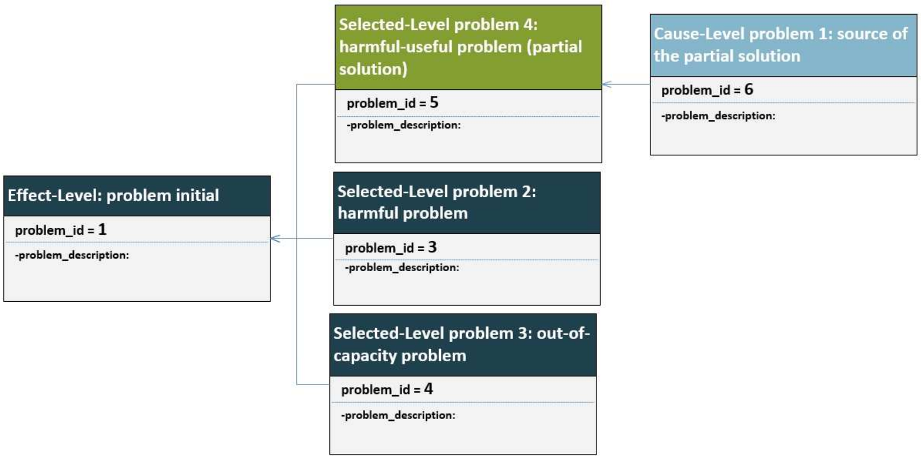


Figure 4. Different types of problems and levels in IPG

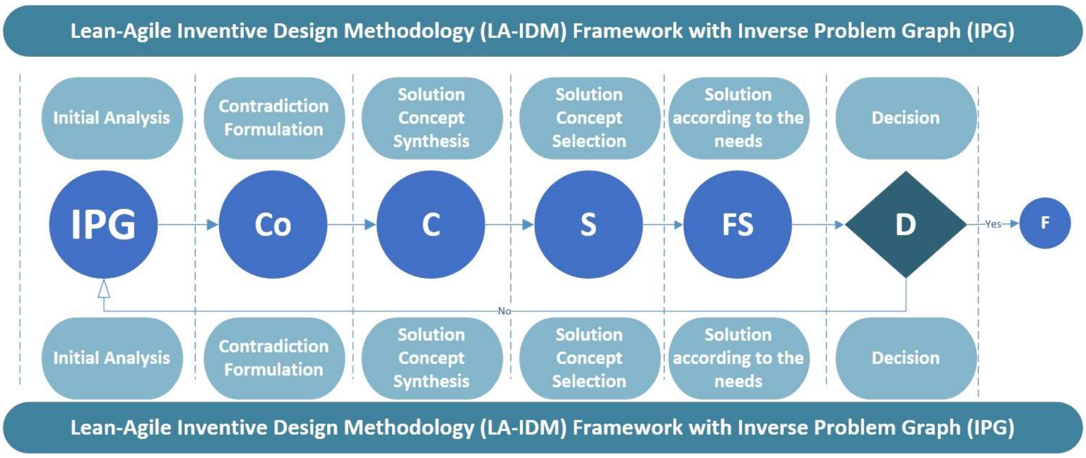


Figure 5. LA-IDM with Inverse Problem Graph

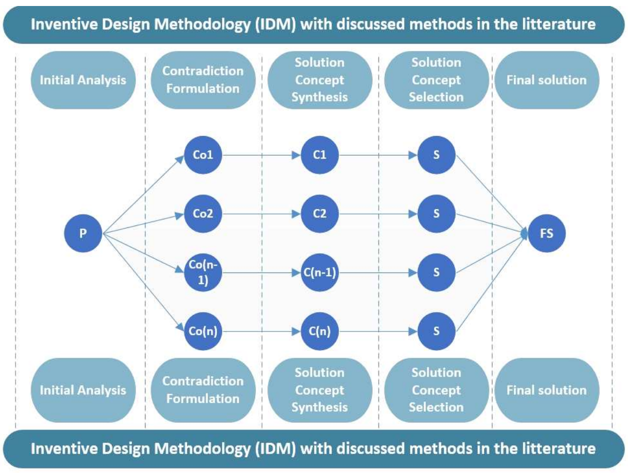


Figure 6. IDM with other discussed methods in the literature review

3.2 Inverse Problem Graph (Ipg)

Our proposed method consists of three phases. In the first phase, the Inverse Problem Graph method helps to perform initial analysis of the problem situation. The second phase refers to the formulation of the contradiction by applying the given parameters of step 7 of the IPG. The applied tool in this phase is called poly-contradiction template [9]. In the third phase, designers apply TRIZ methods such as contradictions matrix and inventive principles to solve the formulated contra–diction. In this paper, we will focus only on the first phase (Phase 1), which consists of 7 steps in the IPG, as Figure 7 shows. These steps are as follows:

Step1: Define the aim of the project: This step is related to the determination of fulfilling the objective of the project. What a designer wants today, respecting actual constraints.

Step 2: Define the initial problem of the IPG: The designers define the initial problem by considering the objective of the project.

Step 3: Find related problems to the initial problem: In the third step, the designers determine the problems, which cause the initial problem. In order to determine them, designers could simply ask the question, "What problems in the Cause-Level cause the initial problem?"

Step 4: Grade problems in terms of importance: The designers should verify the degree of importance of each problem, by asking “What is the problem at the borderline of the company’s activities?” Additionally, they should check its profit for the company, by asking “Which problem can bring the most profit, while minimizing costs?” In each iteration, the designers should accept the most important problem by considering the answer to the questions.

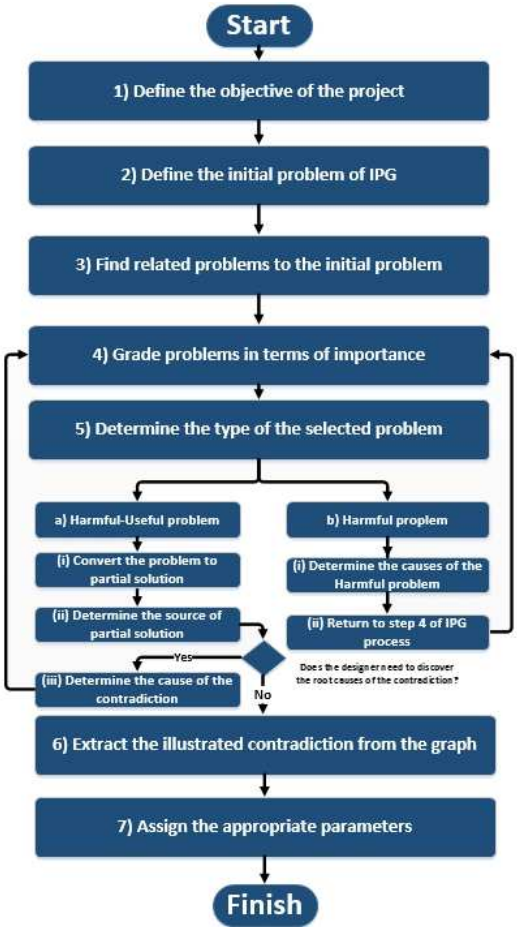


Figure 7. Process of Inverse Problem Graph

Step 5: Determine the type of the selected problem: The designers determine the type of the chosen problem in the previous step by considering the notions existing in the structure of the IPG.

(a) If the selected problem was a Harmful-Useful problem, (i) it is essential to convert the Harmful-Useful problem to a partial solution. (ii) Subsequently, the designers should answer the question: “What problems in the Cause-Level cause this partial solution?” to identify the source of partial solution (causes of partial solution). (iii) In the following, if the designers need to discover the root causes of the contradiction, they could apply the following question: “What problems at the Cause-Level lead to the source of partial solution?”

(b) If the selected problem was a Harmful problem, (i) it is essential to determine the related causes of Harmful problems by answering the question: “What problems at the Cause-Level lead to this Harmful problem?”. (ii) After identifying the potential causes, the designers should go back to step 4 of the process to grade them.

Step 6: Extract the illustrated contradiction of the selected problem from the graph: In this step of the IPG, the designers have to extract the illustrated contradiction of the selected problem from the IPG graph. We should remember that, in each iteration, the designers could select just one contradiction to receive a flow of information.

Step 7: Assign the appropriate parameters: Finally, the designers should respectively assign the evaluation and action parametersto the problems and partial solution, forming the structure of the extracted contradiction.

4. APPLICATION OF PROPOSED METHOD TO COVID-19 CASE STUDY

In this section, in order to illustrate the operation of the proposed approach in a pedagogic way, we decided to rely on a current international situation, that of COVID-19, of which we are not experts, but whose elements allowing the characterization are eminently multidisciplinary and whose sources abound in the literature review. Prior to the confirmation of this topic, as a case study, there was a discussion among the members of our laboratory, concerning the fact that this case is a medical case, and whether we should apply our proposed method to such topic. The reason for this argument is related to the needs of patients, infected with the new 2019 coronavirus, to medical and health specialists for their treatment.

As a result, we can know about this virus and its case as an industrial topic, although this industry needs medical professionals to determine the potential causes and to discover the appropriate solutions. It was also suggested that we propose our solution, which was not satisfactory for a case study in this paper. Our objective in writing this paper was to show IPG's capabilities in formulating a problem situation. That is why we chose COVID-19 as our case study.

The “COVID-19” virus, whose rapid spread is causing a global health emergency, was first detected in December 2019 [3]. The COVID-19 case study aims to identify the causes that make the virus the enemy of humanity in a short period of time, and to propose the solutions suggested by other health specialists. For this purpose, we applied IPG to formulate the contradictions and to solve them by implementing TRIZ methods. In what follows, we explain this application for this case study.

The first phase of the proposal was related to the initial analysis of the problem and the creation of its Inverse Problem Graph (IPG). This phase includes the following steps:

Step1: We defined “To propose some treatments for COVID-19 virus” as the objective of the project, considering that this virus has increased patient mortality worldwide [40].

Step2: We need to determine the initial problem based on the objectives. Hence, we have defined “COVID-19 has fatal consequences on humans” as the initial problem.

Step3: We determined all the Harmful and Harmful-Useful problems associated to the initial problem by asking the question: “What problems in the Cause-Level cause the initial problem?” As a result, we found the following problems and causes through the research that we conducted in the articles on this topic. Firstly, “COVID-19 damages the human heart due to the high expression of ACE2 in this organ ” [41]. Secondly, it mentions the problem “COVID-19 damages the neurons in the brain” [42]. And thirdly, it was the problem “COVID-19 causes lung injury” [43]. Figure 9 shows these problems.

Step 4: We need to grade the problems found and select one of them, which was the most important. Therefore, the problem “COVID-19 damages the human heart due to the high expression of ACE2 in this organ” was selected, showed in the red rectangle in Figure 9, because, according to [44], cardiac injury is a prominent feature of COVID-19, which occurs in 20 % - 30 % of hospitalized patients and leads to 40 % of deaths .

Step5: We need to determine the type of problem selected. Based on the notions presented for the IPG structure, we have concluded that the selected problem is a Harmful problem. Hence, it was necessary to find the causes of this Harmful problem at the Cause-Level of the diagram. Considering the research on the subject COVID-19, we obtained the following problem: “The patients use drugs for cardiovascular diseases, which increase ACE2, to treat heart diseases” [45], which is a Harmful-Useful problem. Consequently, we converted it to the partial solution “To use cardiovascular drugs, which increase the levels of ACE2, to treat heart diseases”, as Figure 8 shows. Then, the source of the partial solution was determined as follows: “Patients suffer from heart disease”. Figure 9 shows the IPG in the first iteration of our case study.

Step 6: The illustrated contradiction of the most important problem in the diagram was extracted, as Figure 10 shows. The figure shows a contradiction between the ability of the heart to perform its intended function and the vulnerability of this organ to the harmful effect of the COVID-19 virus due to the level of ACE2. This means that the efforts to improve heart function by using drugs for cardiovascular diseases could increase its permeability to the virus.

Step 7: We assigned the appropriate parameters to the problems and partial solution of the prior step. Figure 10 illustrates this assessment. The first parameter “Easy access of the virus to the heart cells (Vulnerability of heart to the harmful effect of the virus)” was an evaluation parameter, extracting from the problem “COVID-19 damages the human heart due to the high level of ACE2 in this organ” because COVID-19 hurts the body. Furthermore, we selected “The ability of heart to perform its intended function” as our second assessment parameter because heart diseases have an impact on the intended function of this organ of the body. These parameters were translated to TRIZ parameters in the next phase of the process of constructing the table of contradictions and in the third phase as an input for using the contradiction matrix and extracting inventive principles.

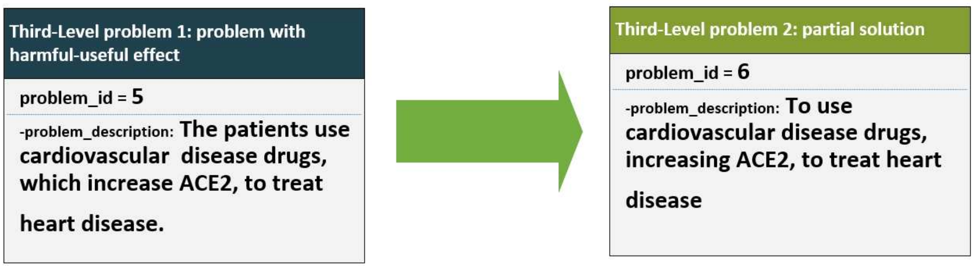


Figure 8. Conversion of the problem to partial solution

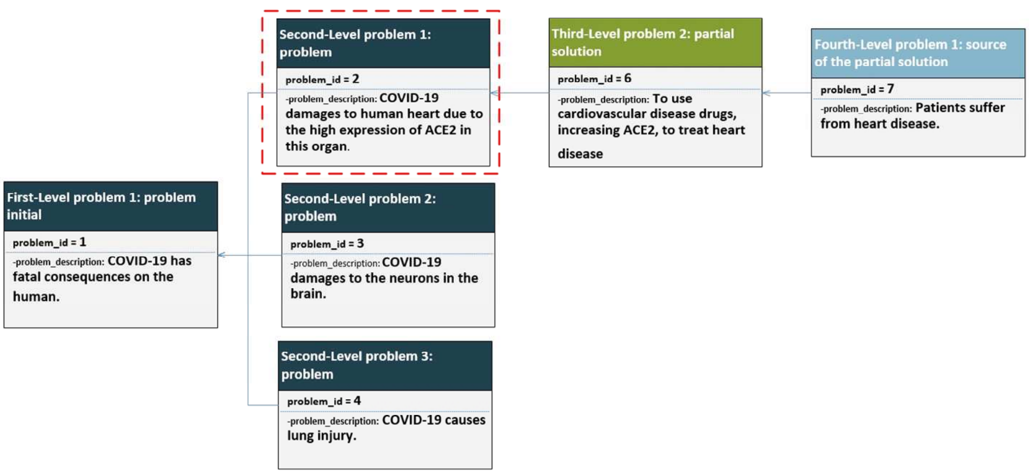


Figure 9. Inverse Problem Graph of the case study in the first iteration

In the second phase of the inventive design, we firstly translated the assigned parameters from step 7 of IPG to the TRIZ parameters. The first evaluation parameter “Easy access of the virus to the heart cells (Vulnerability of the heart to the harmful effect of the virus)” was translated to “External harm affects the heart”. Furthermore, we translated the second evaluation parameter “The ability of the heart to perform its intended function” into “Reliability of the heart”. Subsequently, we applied the TRIZ parameters to construct the poly-contradiction model. As shown in Figure 11, the relationship between the parameters of the model, when using drugs against diseases, we encounter a contradiction between two parameters, “Reliability of the heart” and “External harm affects the heart”. This means that the consumption of heart medicines, which increase the ACE2 level in the heart, could improve the reliability of the heart. However, it could increase the harmful effects of the virus on this organ of the body.

Phase 3 consists of listing the inventive principles by applying the TRIZ’s contradictions matrix and selecting one of them, which is closest to our problem. The list below shows the inventive principles obtained from the intersection of the parameters in the matrix.

1. Principle 27: Cheap short-lived objects
a) Replace an expensive object with a multiple of inexpensive objects
2. Principle 35: Parameter changes
a) Change an object’s physical state
b) Change the concentration or consistency
c) Change the degree of flexibility
d) Change the temperature
e) Change the pressure
f) Change other parameters
3. Principle 2: Taking out
a) Extract or isolate from the object a part or one of its disturbing properties
b) Extract or isolate only the property or the useful part
4. Principle 40: Composite materials
a) Change from uniform to multiple materials where each material is tuned to a particular functional requirement.

According to the existing research on the COVID-19 virus, the virus requires cellular receptors (ACE2) and host cell proteases (TMPRSS2) to enter the cell, as Figure 12 illustrates [46][3][47]. Unlike the cellular receptor (ACE2), the host cell protease (TMPRSS2) is not necessary for the patients. Instead, it helps the virus to access the cell. The host cell protease (TMPRSS2) is therefore disruptive to the cell and body. According to principle 2, if a part of an object has disturbing properties, designers could isolate it. Therefore, isolation of the host cell protease (TMPRSS2) could be a good treatment against the COVID-19 virus. This solution has previously been suggested before in [46] by using Camostatmesylate, which is an inhibitor of TMPRSS2 [48].

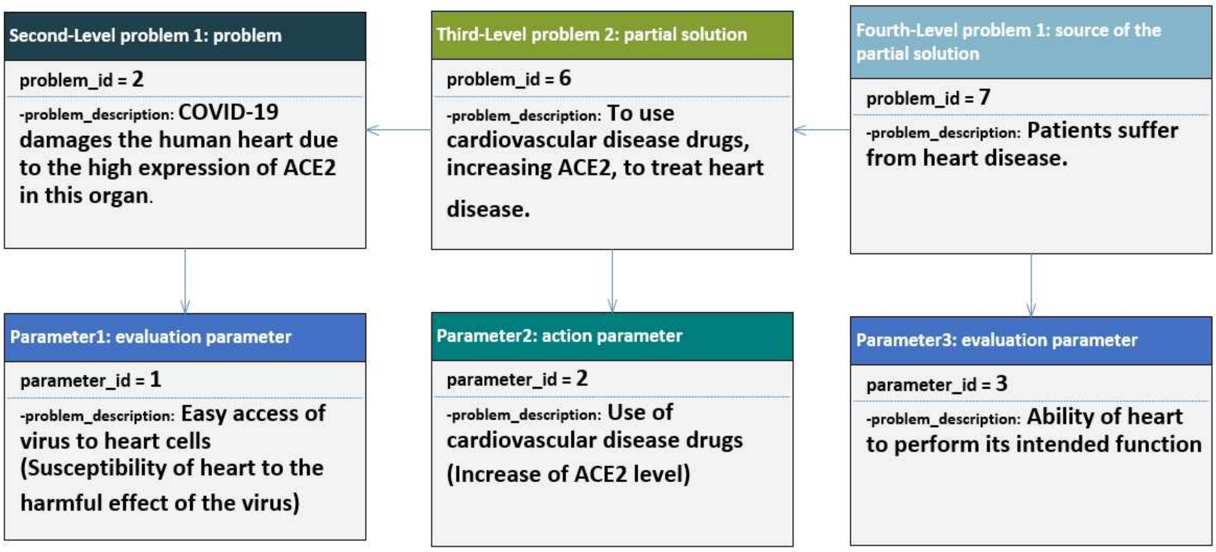


Figure 10. Allocation of the parameters

	Use of cardiovascular disease drugs (Increase in ACE2 level)	
	Yes	No
Reliability of the heart	☺	☹
External harm affects the heart	☹	☺
TRIZ definition of the applied parameters		
Reliability : A system’s ability to perform its intended functions in a predictable manner		
External harm affects the system: Vulnerability of a system to external harmful effects		

Figure 11. Poly-contradiction model of the TRIZ parameters in relation to the assigned parameters of step 7 of the IP

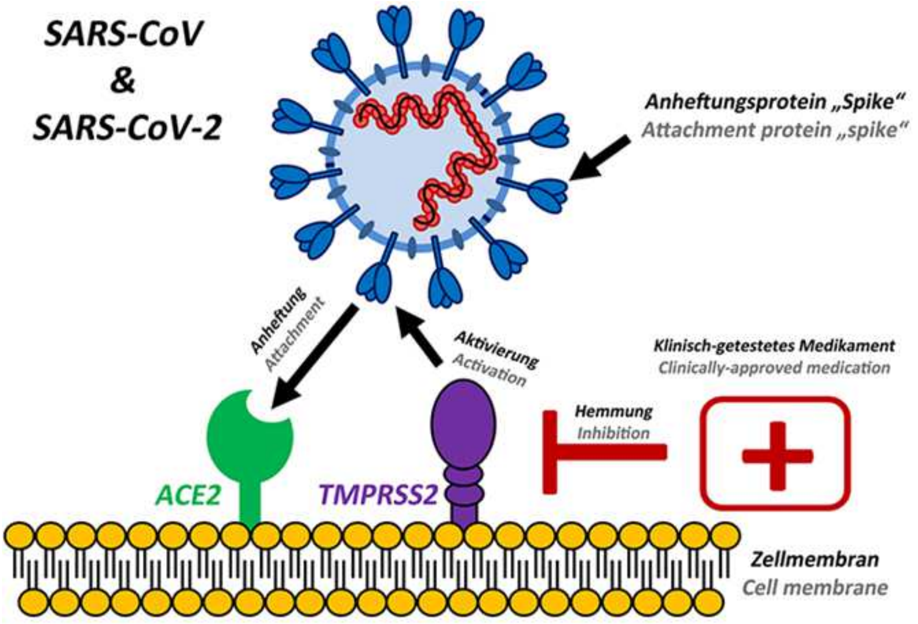


Figure 12. Interaction between COVID-19, ACE2, and TMPRSS2 [46,49]

5. COMPARISON OF THE IPG METHOD WITH CONVENTIONAL METHODS

5.1 Comparison in terms of time

In this section, we first present a quantitative comparison between the Inverse Problem Graph and the Problem Graph methods to show their time differences in the initial analysis and contradiction formulation. This comparison is based on the application of both methods to four projects. In this application, there were two groups of students. To analyze the Problem Graph capability, we asked one of the groups to apply this method. Then, we collected information such as the number of constructed elements and the total time allocated to these constructions. Table 1 shows this collected information. As shown in the table, the students constructed sixteen problems in the Luggage project. Considering that each of these problems took 30 minutes to construct, we obtained 480 minutes as the total time to construct the problems in this project. Similarly, we calculated the total time to construct the remaining elements in the first project to obtain the total time spent in the initial analysis and contradiction formulation phases, which was 1140 minutes (480 min + 360 min + 300 min = 1140 min). Table 1 also demonstrates the total time of these phases in the other three projects. Moreover, the table shows the average time (1235 minutes) to perform the initial analysis and contradiction formulation by applying the Problem Graph.

Table 1: Information Collected from four different student projects

Essential time for the initial analysis and contradiction formulation phases (Problem Graph)				
Project	**Element to construct**	**Construction Time**	**Number of elements in the project**	**Total time**
Luggage	Problem (including general problem)	30 min	16	480 min
	Partial solution	30 min	12	360 min
	Contradiction	20 min	15	300 min
	Total time for the initial analysis and contradiction formulation phases			1140 min
Hammer	Problem (including general problem)	30 min	28	840 min
	Partial solution	30 min	9	270 min
	Contradiction	20 min	4	80 min
	Total time for the initial analysis and contradiction formulation phases			1190 min
Keyboard	Problem (including general problem)	30 min	19	570 min
	Partial solution	30 min	17	510 min
	Contradiction	20 min	23	460 min
	Total time for the initial analysis and contradiction formulation phases			1540 min
Desk lamp	Problem (including general problem)	30 min	11	330 min
	Partial solution	30 min	10	300 min
	Contradiction	20 min	22	440 min
	Total time for the initial analysis and contradiction formulation phases			1070 min
Average time for the initial analysis and contradiction formulation phases				1235 min

Table 2: Collected information from the application of the IPG method to the four student projects

Essential time for the initial analysis and contradiction formulation phases (Inverse Problem Graph)				
Project	**Element to construct**	**Construct time**	**Number of elements in the project**	**Total time**
Luggage	Problem (including initial problem)	30 min	3	90 min
	Partial solution	30 min	1	30 min
	Contradiction	20 min	1	20 min
	Total time for the initial analysis and contradiction formulation phases			140 min
Hammer	Problem (including initial problem)	30 min	4	120 min
	Partial solution	30 min	1	30 min
	Contradiction	20 min	1	20 min
	Total time for the initial analysis and contradiction formulation phases			170 min
Keyboard	Problem (including initial problem)	30 min	**4**	120 min
	Partial solution	30 min	**1**	30 min
	Contradiction	20 min	**1**	20 min
	Total time for the initial analysis and contradiction formulation phases			170 min
Desk lamp	Problem (including initial problem)	30 min	**4**	120 min
	Partial solution	30 min	**1**	30 min
	Contradiction	20 min	**1**	20 min
	Total time for the initial analysis and contradiction formulation phases			170 min
Average time for the initial analysis and contradiction formulation phases				162.5 min

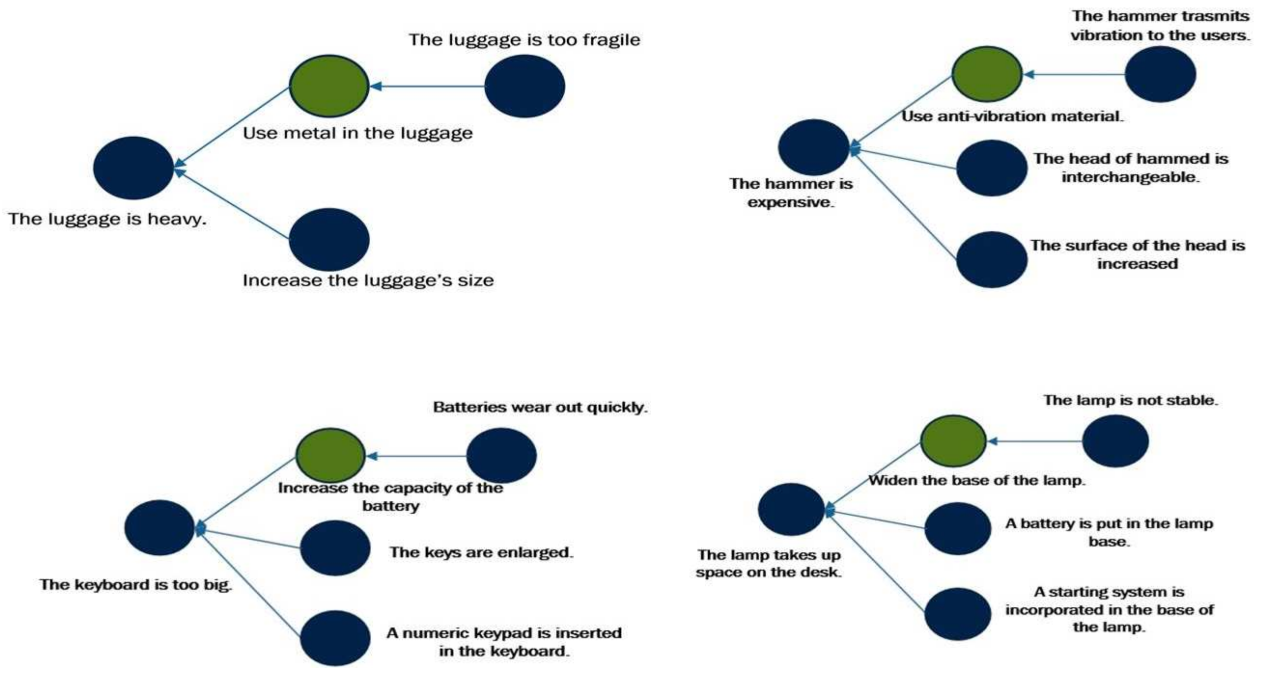


Figure 13. Application of the IPG method to the four student projects

Table 2 shows the information on the capability of the IPG method in formulating the problem situations. To construct this table, we asked the other group to apply our proposal to the same projects mentioned in Table 1. Figure 13 demonstrates the Inverse Problem Graphs related to each project. As Table 2 illustrates, we first calculated the total construction time for each element in four different projects. Then, we obtained the time spent on the initial analysis and the contradiction formulation phases in each project. Table 2 also displays the average time, which was 162.5 minutes, to complete these phases using the IPG method.

Figure 14 shows a comparison between the integrated IPG method and Problem Graph in terms of the total time spent in the initial analysis and contradiction formulation phases of the four projects. Furthermore, the figure shows the average time spent in these phases using our proposal and the classical method.

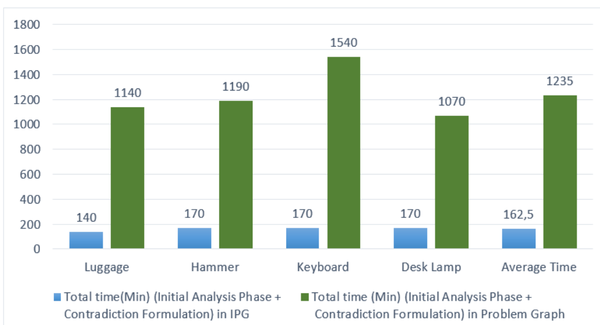


Figure 14. Time-based Comparison of the IPG method and Problem Graph

5.2 Comparison in terms of complexity

In order for the readers of this article to be more aware of the differences in terms of complexity, we also compare our proposal with the NoP method. To perform this comparison, we extracted the information from [50], as shown in Figure 15 and Table 3, in which the authors applied NoP to the 'Biomass Power Plant' case study. Indeed, Table. 3 and Figure 15 (a) & (b) show that the designers have to collect all problems and partial solutions to arrive at a problem at the lower level of a problem situation by applying NoP. For instance, as shown in the table, the designers collected about sixty problems and partial solutions to illustrate contradictions related to problem sixty-eight. Likewise, for the contradiction related to problem forty-eight, they collected about forty problems. From the Inverse Problem Graph, this shortcoming was addressed by providing the possibility of starting directly from a lower level of a problem situation, as illustrated in Figure 15 (c). Figure 15 (d) shows the number of constructed elements, including problems and partial solutions, by applying the IPG and NoP methods.

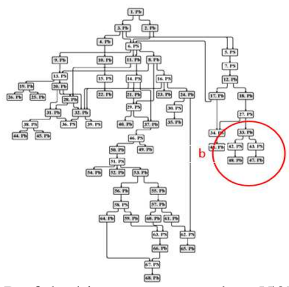
6. DISCUSSION AND CONCLUSION

In this study, we developed a Lean-based method to formulate a problem situation in the initial analysis phase of the systematic innovation processes such as IDM. To develop this method, we first analyzed existing methods that assist the designers in the formulation of problems upstream of innovation projects. Among the elements analyzed, we identified that one point brings them together: they do not consider the time spent collecting information as well as the productivity of the company. Accordingly, we integrated the related features of the analyzed methods, and applied Lean principles to develop a new method, called the Inverse Problem Graph. In what followed, we used the COVID-19 topic to demonstrate the ability of the IPG to formulate contradictions and suggested the solutions, proposed by other health specialists. Finally, we compared our proposal with other reviewed methods in the literature review to highlight its characteristics.

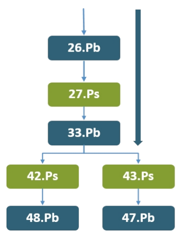
The contribution of this work to the inventive design process reflects in several aspects. First of all, the proposed method optimizes the time taken for problem formulation by keeping only the essential elements of the study to be collected by applying Lean principles. These are, therefore, the elements that are most closely related to the objective retained throughout the process. As a second contribution, it is possible to mention the feature that is added to the method by iteration capacity. Unlike other methods, we did not develop all the chains at the beginning of the project. Instead, we integrated the solution phase in developing the chains of causes.

Table. 3 List of problems related to NoP in Figure 15 , extracted from [50]

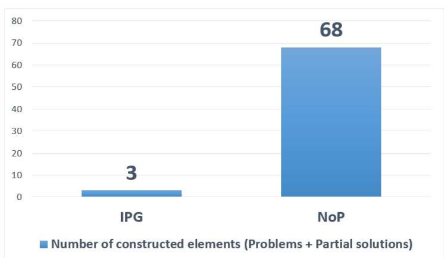
Pb or PS ref.	Description of Problem (Pb) or Partial Solution (PS)	Pb or PS ref.	Description of Problem (Pb) or Partial Solution (PS)
1.Pb	Biomass power plant should be improved.	33.Pb	In order to accumulate more heat, the bed material should stay longer in the combustion chamber.
…	…	…	…
5.Ps	Produces clean biogas.	42.Pb	Decrease speed of movement of the bed material in the combustion chamber.
…	…	…	…
8.Pb	How can one eliminate tar vapour from the biogas?	48.Pb	At a low speed, the bed material will not go through the combustion chamber and transport the heat energy to a gasification chamber.
…	…	68.Pb	High temperature, high speed of flue gases destroy the post combustion chamber at the turn point.



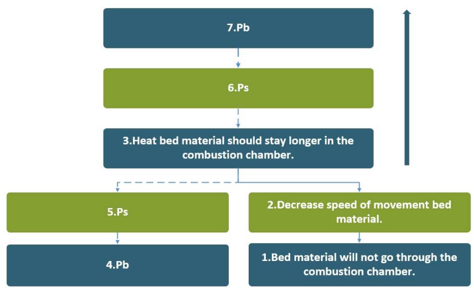
(a) NoP of the biomass power plant [50]



(b) One of the developed chains of biomass power plant and direction of movement in the NoP to find the effects of the main problem



(d) Number of constructed elements by applying IPG and NoP



(c) IPG and the direction of the movement to find the causes of the initial problem

Figure 15. Network of Problem and its difference with the Inverse Problem Graph [50]

Our analysis of these initial results reveals some limitations that we would also like to point out. The first is that the agility of the method depends on the personal knowledge of the designers. This means that if the designers do not have enough information on a subject, they should collect this information in each step of the process by employing the existing documents such as patents or from other people. This collection, regardless of the method, requires a lot of human effort and makes the process time-consuming. One solution for this drawback could be the presence of an automatic system that assists the designers in extracting the information. Secondly, the problem formulation and its agility in our proposal depends on the solution phase. Therefore, it is essential to integrate the method in a process that could link the solution phase more quickly to the initial analysis phase.

Further research and investigation is necessary to access the proposed method and its application. One of our future investigations will focus on integrating the Inverse Problem Graph method in a process that, along with TRIZ tools, could link the solution phase more quickly to the problem formulation phase. The other investigation focuses on developing the tools that could automatically extract the essential information of the IPG by applying machine learning and NLP. Furthermore, it is imperative to develop computer tools that assist the designers at each step of the process.

REFERENCES

[1] G. Stalk, T. M. Hout, 'Competing Against Time', *Res.-Technol. Manag.*, vol. 33, no. 2, pp. 19–24, Mar. 1990, doi: 10.1080/08956308.1990.11670646.

[2] M. A. Cohen, J. Eliasberg, and T.-H. Ho, 'New Product Development: The Performance and Time-to-Market Tradeoff', *Manag. Sci.*, vol. 42, no. 2, pp. 173–186, Feb. 1996, doi: 10.1287/mnsc.42.2.173.

[3] H. Zhang, J. M. Penninger, Y. Li, N. Zhong, and A. S. Slutsky, 'Angiotensin-converting enzyme 2 (ACE2) as a SARS-CoV-2 receptor: molecular mechanisms and potential therapeutic target', *Intensive Care Med.*, vol. 46, no. 4, pp. 586–590, Apr. 2020, doi: 10.1007/s00134-020-05985-9.

[4] A. Zdravkova, I. Mircheski, and S. Sidorenko, 'Bio-inspired approach for innovative design of knee protectors for recreational sports', *FME Transactions*, vol. 48, no. 4, pp. 849–854, 2020, doi: 10.5937/fme2004849Z.

[5] I. Stevanović and B. Rašuo, 'Development of a miniature robot based on experience inspired by nature', *FME Transactions*, vol. 45, no. 1, pp. 189–197, 2017, doi: 10.5937/fmet1701189S.

[6] N. N. Gavrilović, B. P. Rašuo, G. S. Dulikravich, and V. B. Parezanović, 'Commercial aircraft performance improvement using winglets', *FME Transactions*, vol. 43, no. 1, pp. 1–8, 2015, doi: 10.5937/fmet1501001g.

[7] G. Altshuller, *And Suddenly The Inventor Appeared TRIZ*. Technical Innovation Ctr; Édition : 2 (1 mai 1996).

[8] D. D. Sheu, H.-K. Lee, 'A Proposed Classification and Process of Systematic Innovation', *Int. J. Syst. Innov.*, vol. 1, no. 1, p. 20, 2010.

[9] D. Cavallucci, 'Designing the Inventive Way in the Innovation Era', in *An Anthology of Theories and Models of Design*, A. Chakrabarti and L. T. M. Blessing, Eds. London: Springer London, 2014, pp. 237–262. doi: 10.1007/978-1-4471-6338-1_12.

[10] D. Cavallucci and I. Strasbourg, 'From TRIZ to Inventive Design Method (IDM): towards a formalization of Inventive Practices in R&D Departments', p. 2, 2012.

[11] C. Zanni-Merk, D. Cavallucci, and F. Rousselot, 'Use of formal ontologies as a foundation for inventive design studies', *Comput. Ind.*, vol. 62, no. 3, pp. 323–336, Apr. 2011, doi: 10.1016/j.compind.2010.09.007.

[12] R. Slim, R. Houssin, A. Coulibaly, M. Hanifi, and H. Chibane, 'Framework for resolving problems resulting from lean integration from the early design phases of production 3D printing machine', *FME Transactions*, vol. 49, no. 2, pp. 279–290, 2021, doi: 10.5937/fme2102279S.

[13] M. Hanifi, H. Chibane, R. Houssin, and D. Cavallucci, 'Contribution to TRIZ in Combining Lean and Inventive Design Method', in *Systematic Complex Problem Solving in the Age of Digitalization and Open Innovation*, vol. 597, D. Cavallucci, S. Brad, and P. Livotov, Eds. Cham: Springer International Publishing, 2020, pp. 280–291. doi: 10.1007/978-3-030-61295-5_23.

[14] R. H. Da Silva, P. C. Kaminski, and F. Armellini, 'Improving new product development innovation effectiveness by using problem solving tools during the conceptual development phase: Integrating Design Thinking and TRIZ', *Creat. Innov. Manag.*, vol. 29, no. 4, pp. 685–700, Dec. 2020, doi: 10.1111/caim.12399.

[15] W. Yan, H. Liu, Y. Liu, J. Wang, C. Zanni-Merk, and D. Cavallucci, 'Latent semantic extraction and analysis for TRIZ-based inventive design', p. 21.

[16] K.-H. Chai, J. Zhang, and K.-C. Tan, 'A TRIZ-Based Method for New Service Design', *J. Serv. Res.*, vol. 8, no. 1, pp. 48–66, Aug. 2005, doi: 10.1177/1094670505276683.

[17] D. Cavallucci, F. Rousselot, C. Zanni, 'Assisting R&D activities definition through problem mapping', *CIRP J. Manuf. Sci. Technol.*, vol. 1, no. 3, pp. 131–136, Jan. 2009, doi: 10.1016/j.cirpj.2008.09.014.

[18] A. Souili and D. Cavallucci, 'Automated Extraction of Knowledge Useful to Populate Inventive Design Ontology from Patents', in *TRIZ – The Theory of Inventive Problem Solving*, D. Cavallucci, Ed. Cham: Springer International Publishing, 2017, pp. 43–62. doi: 10.1007/978-3-319-56593-4_2.

[19] M. Hanifi, H. Chibane, R. Houssin, D. Cavallucci, 'Improving Inventive Design Methodology's Agility', in *New Opportunities for Innovation*

Breakthroughs for Developing Count–ries and Emerging Economies, vol. 572,

[20] R. Benmoussa, R. De Guio, S. Dubois, and S. Koziołek, Eds. Cham: Springer International Publishing, 2019, pp. 216–227. doi: 10.1007/978-3-030-32497-1_18.

[21] G. Kumar and P. K. Bhatia, 'Impact of Agile Methodology on Software Development Process', *Int. J. Comput. Technol. Electron. Eng. IJCTEE*, vol. 2, no. 4, pp. 46–50, 2012.

[22] H. Chen and R. Taylor, 'Exploring the impact of lean management on innovation capability', in *PICMET '09 - 2009 Portland International Conference on Management of Engineering & Technology*, Portland, OR, USA, Aug. 2009, pp. 826–834. doi: 10.1109/PICMET.2009.5262042.

[23] J. Womack, D. Jones, D. Roos, and D. Carpenter, 'The machine that changed the world', *Rawson Assoc.*, 1991.

[24] J. Womack and D. Jones, 'BANISH WASTE AND CREATE WEALTH IN YOUR CORPORATION', *Recuperado Httpwww Kvimis Co Insiteskvimis Co InfilesebookattachmentsJames*, 2003.

[25] P. Ugochukwu, J. Engstrom, and J. Langstrand, 'LEAN IN THE SUPPLY CHAIN: A LITERATURE REVIEW', *Manag. Prod. Eng. Rev.*, vol. 3, no. 4, p. 10, 2012.

[26] K. C. Wong, K. Z. Woo, and K. H. Woo, 'Ishikawa Diagram', in *Quality Improvement in Behavioral Health*, W. O'Donohue and A. Maragakis, Eds. Cham: Springer International Publishing, 2016, pp. 119–132. doi: 10.1007/978-3-319-26209-3_9.

[27] C. Dobrusskin, 'On the Identification of Contradictions Using Cause Effect Chain Analysis', *Procedia CIRP*, vol. 39, pp. 221–224, 2016, doi: 10.1016/j.procir.2016.01.192.

[28] Valeri Souchkov, 'Application of Root Conflict Analysis (RCA+) to formulate inventive problems in the maritime industry', *51 Sci. J. Marit. Univ. Szczec.*, vol. 123, no. 51, 2017, doi: 10.17402/225.

[29] V. Souchkov, 'Root Conflict Analysis (RCA+): Structured Problems and Contradictions Mapping', *Proc. TRIZ Future Conf. Graz Austria*, p. 8, 2005.

[30] V. Souchkov and R. Hoeboer, 'TRIZ IN BUSINESS: APPLICATION OF RCA+ TO IDENTIFY AND SOLVE CONFLICTS RELATED TO BUSINESS PROBLEMS', *ETRIA TFC*, pp. 9--11, 2006.

[31] M.-G. Lee, L. Chechurin, and V. Lenyashin, 'Introduction to cause-effect chain analysis plus with an application in solving manufacturing problems', *Int. J. Adv. Manuf. Technol.*, vol. 99, no. 9–12, pp. 2159–2169, Dec. 2018, doi: 10.1007/s00170-018-2217-1.

[32] N. Becattini, G. Cascini, and F. Rotini, 'OTSM-TRIZ Network of Problems for Evaluating the Design Skills of Engineering Students', *Procedia Eng.*, vol. 131, pp. 689–700, 2015, doi: 10.1016/j.proeng.2015.12.356.

[33] H. Chibane, S. Dubois, and R. De Guio, 'Innovation beyond optimization: Application to cutting tool design', *Comput. Ind. Eng.*, vol. 154, p. 107139, Apr. 2021, doi: 10.1016/j.cie.2021.107139.

[34] A. Souili, D. Cavallucci, F. Rousselot, and C. Zanni, 'Starting from Patents to Find Inputs to the Problem Graph Model of IDM-TRIZ', *Procedia Eng.*, vol. 131, pp. 150–161, 2015, doi: 10.1016/j.proeng.2015.12.365.

[35] S. Vinodh and D. Joy, 'Structural Equation Modelling of lean manufacturing practices', *Int. J. Prod. Res.*, vol. 50, no. 6, pp. 1598–1607, Mar. 2012, doi: 10.1080/00207543.2011.560203.

[36] P. Hines and D. Taylor, *Going lean: a guide to implementation*, vol. 1. Cardiff, U.K.: Lean Enterprise Research Centre, 2000.

[37] B. P. Nepal, O. P. Yadav, and R. Solanki, 'Improving the NPD Process by Applying Lean Principles: A Case Study', *Eng. Manag. J.*, vol. 23, no. 3, pp. 65–81, Sep. 2011, doi: 10.1080/10429247.2011.11431910.

[38] D. Cavallucci, F. Rousselot, and C. Zanni, 'Initial situation analysis through problem graph', *CIRP J. Manuf. Sci. Technol.*, vol. 2, no. 4, pp. 310–317, Jan. 2010, doi: 10.1016/j.cirpj.2010.07.004.

[39] V. V. Souchkov, 'A Guide to Root Conflict Analysis (RCA+). ICG Training \& Consulting', p. 26, 2018.

[40] D. Cavallucci, F. Rousselot, and C. Zanni, 'Linking Contradictions and Laws of Engineering System Evolution within the TRIZ Framework', *Creat. Innov. Manag.*, vol. 18, no. 2, pp. 71–80, Jun. 2009, doi: 10.1111/j.1467-8691.2009.00515.x.

[41] M. L. Sun, J. M. Yang, Y. P. Sun, and G. H. Su, '[Inhibitors of RAS Might Be a Good Choice for the Therapy of COVID-19 Pneumonia]', *Zhonghua Jie He He Hu Xi Za Zhi Zhonghua Jiehe He Huxi Zazhi Chin. J. Tuberc. Respir. Dis.*, vol. 43, no. 0, p. E014, Feb. 2020, doi: 10.3760/cma.j.issn.1001-0939.2020.0014.

[42] L. Chen, X. Li, M. Chen, Y. Feng, and C. Xiong, 'The ACE2 expression in human heart indicates new potential mechanism of heart injury among patients infected with SARS-CoV-2', *Cardiovasc. Res.*, vol. 116, no. 6, pp. 1097–1100, May 2020, doi: 10.1093/cvr/cvaa078.

[43] A. M. Baig, A. Khaleeq, U. Ali, and H. Syeda, 'Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host–Virus Interaction, and Proposed Neurotropic Mechanisms', *ACS Chem. Neurosci.*, vol. 11, no. 7, pp. 995–998, Mar. 2020, doi: 10.1021/acschemneuro.0c00122.

[44] J. J. Marini and L. Gattinoni, 'Management of COVID-19 Respiratory Distress', p. 2, 2020.

[45] A. Akhmerov, E. Marbán, 'COVID-19 and the Heart', *Circ. Res.*, vol. 126, no. 10, pp. 1443–1455, May 2020, doi: 10.1161/CIRCRESAHA.120. 317055.

[46] J. Guo, Z. Huang, L. Lin, and J. Lv, 'Coronavirus Disease 2019 (COVID-19) and Cardiovascular

Disease: A Viewpoint on the Potential INfluence of Angiotensin-Converting Enzyme Inhibitors/Angi–otensin Receptor Blockers on Onset and Severity of Severe Acute Respiratory Syndrome Coronavirus 2 Infection', *J. Am. Heart Assoc.*, vol. 9, no. 7, Apr. 2020, doi: 10.1161/JAHA.120.016219.

[47] M. Hoffmann *et al.*, 'SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor', *Cell*, Mar. 2020, doi: 10.1016/j.cell.2020.02.052.

[48] K. J. Clerkin *et al.*, 'Coronavirus Disease 2019 (COVID-19) and Cardiovascular Disease', *Circulation*, p. CIRCULATIONAHA.120.046941, Mar. 2020, doi: 10.1161/CIRCULATIONAHA.120. 046941.

[49] M. Kawase, K. Shirato, L. van der Hoek, F. Taguchi, and S. Matsuyama, 'Simultaneous Treatment of Human Bronchial Epithelial Cells with Serine and Cysteine Protease Inhibitors Prevents Severe Acute Respiratory Syndrome Coronavirus Entry', *J. Virol.*, vol. 86, no. 12, pp. 6537–6545, Jun. 2012, doi: 10.1128/JVI.00094-12.

[50] Q. Kleinebeckel, 'Covid-19: Der Weg in die Wirtszelle', *heise online*. https://www.heise.de/tp/features/Covid-19-Der-Weg-in-die-Wirtszelle-4678227.html (accessed Apr. 30, 2020).

[51] N. Khomenko, R. D. Guio, L. Lelait, and I. Kaikov, 'A framework for OTSM TRIZ-based computer support to be used in complex problem management', *Int. J. Comput. Appl. Technol.*, vol. 30, no. 1/2, p. 88, 2007, doi: 10.1504/IJCAT.2007.015700.

IPG КАО НОВИ МЕТОД ЗА ПОБОЉШАЊЕ ФЛЕКСИБИЛНОСТИ ПОЧЕТНЕ АНАЛИЗЕ ИНВЕНТИВНОГ ДИЗАЈНА

М. Ханифи, Х. Шибан, Р. Хусин, Д. Кавалучи

Вредност TRIZ метода као неопходног метода је већ одавно доказана у индустријском свету. Истра–живачи дизајна испитују његова ограничења и успели су да их превазиђу систематичнијим приступима. Један од таквих приступа је Метод инвентивног дизајна (IDM) о коме се расправља у неколико радова и који је примењен у индустрији. Сматра се да је бољи од TRIZ метода, мада, ипак, има неке недостатке у смислу временски захтевне примене. Предмет нашег рада је IDM процес. Покушали смо да одредимо све области његове неефикасности и да при том сачувамо све његове остварене резултате. Наш приступ се састоји у примени Lean правила на IDM. Резултат представља Метод инверзног графа проблема (IPG), инспирисаног методом IDM, али знатно напреднијег са аспекта уштеде времена у ангажовању стручњака и очувању инвентивних исхода. Чланак приказује наш приступ у констру–исању овог новог метода.