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Abstract. The paper presents a research aimed at developing a computer framework to support the analysis of inventive problems according to the logic of TRIZ (Theory of Inventive Problem Solving). The output of the dialogue-based procedure consists in a set of terms, viable to speed up a proper knowledge search within technical and scientific information sources. A dialogue-based architecture allows to support also users without any TRIZ background. The proposed system, although still at a prototype stage, has been tested with students at Politecnico di Milano and at the University of Florence. The paper outlines the structure of the algorithm and the results of the first validation activity.

Keywords: Problem Solving, Conceptual Design, OTSM-TRIZ, Computer-Aided Innovation, Dialogue-Based System

1 Introduction

"It is necessary to innovate to be competitive, it is necessary to enhance problem solving skills to develop valuable innovations", is the common mantra both in the industrial world and in the product development research domain. According to the authors' experience, among the methodologies supporting the solution of inventive problems, TRIZ (Theory of Inventive Problem Solving) has unique and precious characteristics to address these issues, despite its dissemination and development are too often based on practitioners' initiatives, rather than collective and scientific discussions.

Several organizational and educational models have been proposed so far, as in Cascini et al. (2008), but several critical open issues still remain. "Simplified TRIZ", too often intended as a fuzzy application of the contradiction matrix and the inventive principles, is closer to a brainstorming session with guided "stimuli" than to TRIZ problem solving process, and indeed its potential is limited. Thus, a conflict takes place between a proper assimilation of the TRIZ "way of thinking" and the time required to learn the theory and practice its tools. The conflict is even tougher for SMEs, since each employee typically covers several roles, resulting in inadequate time and efforts dedicated to TRIZ learning. Several TRIZ-based software applications have been proposed in the market since the '90s, but these systems are not useful to speed up the learning process and they are marginally usable by people with no TRIZ background.

Within this context, the authors have started a research activity aimed at defining a new role for TRIZ-based computer applications, i.e. problem-solving "coaches" for non-trained users. According to the authors' intention, a designer with no TRIZ background should be able to improve his problem solving capability, being guided by a computer application since the first usage of the software; at the same time the user should gradually acquire the ARIZ logic through a learn-by-doing process. The present paper starts with an analysis of the scientific literature relevant to the scopes of the present research (Section 2). The following section proposes the structure of an original dialogue-based system, founded on TRIZ logic and suitable for software implementation. Finally, the testing activity involving MS degree and PhD students is described and discussed to draw the conclusions about the achieved results (Sections 4-5).

2 Related art

In literature there is a plenty of definitions of the term "invention": among the others, for the scopes of the present paper, it is useful to mention the followings: (i) according to Patent Law a technical solution is inventive when it is useful, novel (no single prior art reference shows the identical development), and unobvious to a person "skilled in the art"; (ii) Cavallucci et al. (2009) associate the concept of invention to the transfer of knowledge between different fields of application. The first definition is here assumed as the reference to identify an invention, since it is more universally accepted, at least in the industrial world; nevertheless, the second definition is relevant for a wide class of “inventive problems” and requires a specific solving approach.

As well, “difficult problems”, according to Funke and Fresch (2007), have at least one of four characteristics that make them hard to solve: intransparency, whereas some elements required to achieve the solution are not known due to the ill-definition of the problem itself; complexity, due to the great number of parameters of the technical system(s) and their mutual connections; dynamics, due to either time-dependent characteristics of relevant features, or to the need of achieving the solution under time pressure; politely, which means that the problem is characterized by multiple, non-compatible goals.

Technical problems can be also distinguished between inventive and non-inventive. Demands and cognitive processes make the differences in this distinction. According to the above mentioned definitions, non-inventive problems don’t require any inventive step, thus they are related to situations where the desired outcome can be achieved just by means of an optimal adjustment of system parameters. On the contrary, inventive problems are characterized by at least two conflicting requirements that cannot be satisfied by choosing the optimized values for system parameters.

The paper proposes a framework for Computer-Aided systems to face and consequently solve:

- difficult problems by both clarifying their definition and prioritizing the objectives;
- inventive problems by the search of conflicting requirements and the identification of features that the technical solution should have;
- non-typical problems by supplying the user with useful information from various domains.

2.1 Problem Solving approaches

Technical systems are continuosuly expected to provide higher performances, reduced resources consumption and harmful side effects. These emerging demands typically bring to design conflicts. Whenever the optimization of the values of the conflicting design parameters allows to satisfy system demands within the established constraints, the solution does not require any inventive activity. Besides, when two or more requirements appear as non-mutually compatible just by adapting certain values of the design parameters, a paradigm shift is needed.

The creativity leaps underneath the inventive process have been deeply studied since the ‘70s both to understand human thinking and to provide an efficient way to improve the problem solving activity. With a particular emphasis, Simon (1973) distinguishes between ill-structured and well-structured problems and observes that the problem solving approach should be the same, regardless of the problem structure. In a recent paper, Dorst (2006) calls into question the differences claimed by Simon between well-structured and ill-structured problems, highlighting that those differences mainly reside in the skills of the problem solver. Therefore, the designer’s subjectivity becomes relevant for the design process, since the greatest part of its creative contribute is spent in the redefinition of the problem in different terms. To this end, particular attention should be paid towards the designer’s interpretation of the problem, taking into account both his knowledge and his methodological approach. Moreover, it is worth to distinguish between cognitive and systematic features of the employed methods, in order to highlight their role within the design activity.

Cognitive approaches are focused on creative thinking features like analogy, abstraction and references to previous experiences by associations of ideas. Furthermore, they can be used regardless of the technical/industrial domain and the increase of their effectiveness must rely on multidisciplinary working teams composed by creative people. Some methods leverage tacit knowledge, stimulate “cross-fertilization” thinking processes and individual creative attitude upon appropriate conditioning techniques. Others rely on explicit knowledge such as information and data available in handbooks, patents and scientific papers. One of the greatest restrictions of these methods stands in their limited versatility, since they are hard to be generalized for different expertise domains. On the other hand, systematic approaches of problem solving are characterized by linear and “step-by-step” procedures that drive the design process, but usually cover a narrower solution space.

Despite many creative process models and techniques might be considered, as those reviewed by Howard et al. (2008), the discussion is here limited to the main differences and weak points of these two classes of methods.

Among the former, Brainstorming-like methods are characterized by a poorly efficient trial and error approach which requires a time consuming validation stage. Moreover, a brainstorming session intrinsically leverages only the knowledge of the individuals involved in the idea generation process. Besides, cognitive methods which rely on a computerized Knowledge Base, such as Case-Based Reasoning (CBR) have proved to be effective just on narrow domains. Among the methods based on systematic procedures for problem solving, Constraint Satisfaction Problem (CSP) techniques search suitable solutions for over-constrained problems when standard optimization algorithms fail to identify any solution. Nevertheless, all the methods proposed so far, don't allow the introduction of new variables in the problem model, thus reducing the chance of inventive solutions. TRIZ is acknowledged as a methodology providing systematic means for problem solving. Its main tool is the so called ARIZ algorithm (Altshuller, 1999), a step-by-step procedure that brings from the analysis of two contradictory requirements to the synthesis of a new technical system, capable to overcome the underlying contradiction. Indeed, this method cannot be considered as completely systematic, since "ARIZ is a tool to aid thinking, but it cannot replace thought itself, if the human brain does not use the power of a lifetime's knowledge, a lot of potential associations and images would be neglected" (Khomenko et al. 2007). Both cognitive and systematic methods of problem solving have strong and weak points. Therefore it is important to combine the power of systematic approaches, in order to overcome through efficient processes the boundaries of personal creativity, with the capability of cognitive methods to leverage individual tacit knowledge.

2.2 Computer-Aided systems for problem solving

The domain of Computer Aided Innovation (CAI) includes systems aimed at assisting Inventive Problem Solving by stimulating creativity and guiding towards suitable problem solving paths. In the last decade, Information Technology systems have substantially fostered a shared vision of creative patterns among different disciplines, resulting in a consistently growing interest in creativity concept. This led towards the birth of a novel and fertile field of research, namely the interplay between creativity stimulation and computer systems. Given the development of software systems that support human creativity, Lubart (2005) proposes a classification among the ways such aid is provided, ordered on the basis of the growing degree of machine involvement: *(i)* by facilitating the management of the working process, encouraging the perseverance of designer in the research of innovative solutions; *(ii)* by easing the communication between design team members, since circulation and integration of ideas play a relevant role in the creative process; *(iii)* by aiding the designer with a coaching activity, acting as an expert system that guides the user throughout cognitive processes; *(iv)* by cooperating in the creative process, thanks to the Artificial Intelligence systems that contribute to ideas generation.

It is beyond the objective of this manuscript to provide a state of the art of CAI tools; however, it is worth to notice that none of the existing software systems implementing any of the above mentioned problem solving methodologies provides adequate means to overcome the abovementioned lacks and limitations. Among the others, TRIZ based tools fail to reproduce the richness of the theory and its abstraction capabilities and they consistently require an adequate TRIZ background to bring proper benefits.

3 Dialogue-based system to support the analysis of an inventive problem

The considerations reported in the previous section have been the basis for the selection of the theoretical pillars and models to build a Computer-Aided problem solving framework. This section briefly mentions these reference items and describes the structure of the original algorithm developed by the authors as the foundation for a problem solving application. Due to space limitations it is not possible to report the detailed algorithm constituted by more than 150 nodes related to possible interactions with the user. Nevertheless, the authors are available to share the prototype implementation with all the researchers interested in contributing to the development of the system.

3.1 System Requirements

As stated above, a specific goal of the present research is to allow even users without vocational experience to achieve viable conceptual solutions. Moreover, the recourse to time-consuming specialization courses has to be excluded, since this issue is extremely critical for the acceptance by SMEs. For the same reason, particular attention has to be paid towards the removal of TRIZ specific terminology. Thus the application has to embed TRIZ models, but the user interface has to be built through a common language, using terms and concepts introduced by the designer himself at the greatest extent.

Literature describes how much time the designer have to spend in order to gather useful information during the conceptual design stage. At the same time engineering designers, especially those with limited experience, are not always aware of the information they require and generally prefer to source knowledge and information through informal interactions with their colleagues. Besides, designers will rely more and more on information captured and stored independently of human memory. These reasons provide compelling evidence about the need to quickly and correctly formulate queries for the investigation of knowledge databases. With the aim of speeding up the search for valuable information, it is worth to focus the analysis of the encountered problem, so that the main criticalities are individuated, as well as the most characterizing technical parameters, elements of the system, features. The tool therefore requires to guide the designer in an accurate and systematic examination of the problem to be faced, clarifying the scopes and the priorities in the solution search, especially in cases characterized by multiple tasks, complex situations and tangled interrelations among parameters, effects and physical phenomena.

3.2 OTSM-TRIZ models as a meta-cognition framework for inventive problem solving

As stated in section 2, it is necessary to reach a synthesis beyond the dichotomy between cognitive and systematic approaches to problem solving, in order to avoid trial and error, build efficient procedures, leverage the available knowledge resources of individuals and teams and highlight knowledge lacks to be covered with new information sources.

According to the authors' experience, OTSM-TRIZ (Cavallucci and Khomenko, 2007) provides a comprehensive and organic suite of models describing the classical TRIZ problem solving process through the explicit integration of cognitive elements. These models, namely Hill model (abstraction-synthesis); Tongs model (from current situation to ideality, barriers identification); Funnel model (convergent process); System Operator (system thinking); should not be considered as alternative paths for transforming a problematic situation into a solution, but as complementary descriptions of the characteristics of an efficient problem solving process.

Within the methods supporting conceptual design with an intensive human involvement, which are currently deemed to be more reliable, a dialogue-based system is suitable to embody the selected reference models. Through a dialogue-based system undertaking the abstraction process, a systematic succession of questions is viable to support the investigation of the problem according to the TRIZ logic.

3.3 Description of the algorithm

The original contribution of this paper is constituted by an algorithm, for problem analysis and solving, structured in the form of a dynamic dialogue, suitable for implementation in a software application. The underpinning logic of OTSM-TRIZ and several classical TRIZ tools are integrated in order to widely describe the topic of the investigation and to remark the most relevant issues to be considered for the problem solving activity and, if necessary, for the knowledge search. The dialogue based system helps at first the user in exploiting his know how by suggesting problem solving paths that don't require external expertise to be implemented. Thanks to the investigation of the parameters affecting the undesired issues arising in the system, the designer individuates factors to be modified in order to reformulate the problem as a typical case. Moreover, the algorithm provides indications for suitable problem solving alternatives, by means of different TRIZ tools, e.g. separating in time/space, trimming low-valued components, opportunities to turn the undesired effect into a useful output, re-thinking the ways to perform the main function or to deliver the same benefits.

In order to fulfil the requirements and to cover all the options for problem solving and knowledge search, the framework of the algorithm includes a set of complementary logical blocks: the network of links among the blocks and the single nodes of the algorithm determine an extensive bundle of paths and cycles to refine the problem formulation (Fig. 1). The following measures have been taken: *(i)* the nodes of the algorithm are either open questions, choices or messages intended to provide proper hints in performing the problem solving process; *(ii)* questions and suggestions resort to previously introduced terms and items; exemplary answers are supplied, in order to clarify the purpose of the open questions; *(iii)* the questioning procedure is rich of checks in order to verify the correctness of the user's inputs and to provide him a feedback about the ongoing process.

With the objective of addressing the user towards the most proper problem description, the algorithm performs a preliminary distinction among tasks concerning the elimination of drawbacks, the implementation of new useful functions and the enhancement of systems with under-performances.

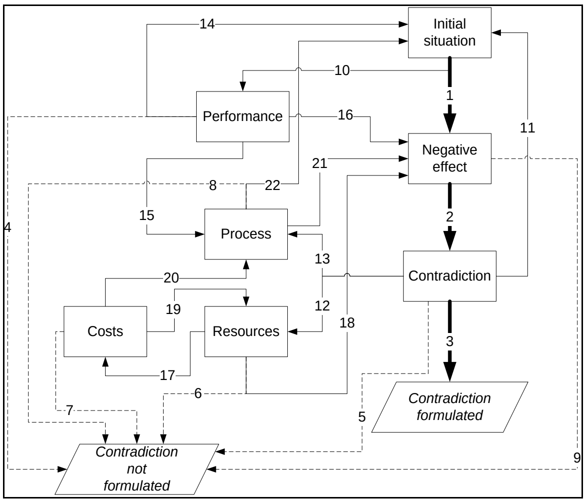

Fig. 1. Network of logical blocks and outputs of the questioning procedure

The individuation of an undesired effect leads to the investigation of the features and the phenomena that provoke it and, subsequently, to their abstraction (Hill model) through the formalization of a physical contradiction, grounded on a control parameter and the mismatching outputs depending on the value it assumes. The most straightforward path for formulating the contradiction, highlighted in Fig. 1 with thicker lines, involves the accomplishment of three logical blocks, intended to assess the initial situation (labelled as IS), to define the arising undesired effect (NE) and to identify the conflicting requirements (AR).

However, further ways are foreseen to depict the problem, since several matters can hinder a thorough description of the system under investigation. In case of any circumstance impeding the definition of a contradiction, the algorithm is designed to investigate a wide set of features viable to constitute the core of elements and terms to suggest solution paths or to be sought in proper knowledge bases. The designer is then guided to analyze the circumstances that determine missing functions or cause under-performances (PE), to pinpoint the resources needed by the system to work correctly (RE), to focus on the reasons that imply high costs (CO), to investigate further problems arising during the manufacturing of products or the delivering of services (PR). Eventually, the absence of a contradiction is due to any of the followings (highlighted in Fig. 1 with dotted lines):

- the user hasn't seized any possibility to modify the studied system and the phenomena that provoke certain underperformances (line 4);
- the attempts to identify a parameter entailing conflicting requirements have failed (line 5);
- the user hasn't succeeded to individuate a proper characterization of the undesired effect in terms of required resources (line 6), high costs (line 7) or problems having reference to any stage of the system lifecycle, whose features are influenced by the design and manufacturing/delivering process (line 8);
- certain criticalities are not considered worth to be further analyzed (line 9).

3.3.1 The logical block Initial Situation (IS block)

The block is aimed at defining, at first, the technical system to be analyzed, its overall goal and the main function it performs. The beneficiary of the system and the object subjected to the main function of the system are identified. The designer is then asked to characterize the technical device under investigation following the hierarchical logic of the System Operator and thus delineating the most relevant operative conditions to perform the function. The user, in order to thoroughly describe the initial situation, is required to delimitate the operative space and time involved when the function is delivered. If the designer acknowledges missing functions or relevant under-performances, he is addressed towards the block Performance (line 10), otherwise he is redirected to the block Negative Effect (line 1).

3.3.2 The logical block Negative Effect (NE block)

The block aims at investigating the undesired effect that arises in the system, as well as its negative consequences. The user is required to indicate which element causes the appearance of the negative effect, the operative space and time of such harmful function, alike in ARIZ steps 2.1 and 2.2. A further check is carried out in order to verify whether the removal of the element, responsible for the undesired effect, implies any negative consequence. The accomplishment of the NE block leads the user towards the set of questions that check the existence of contradiction (AR block, line 2).

3.3.3 The logical block Contradiction (AR block)

The block is supposed to identify a TRIZ physical contradiction according to the logic of the Tongs model. The user is requested to focus on the parameters, concerning the previously identified element, that influence the extent of the negative effect. The consequences of modifying the parameters, i.e. reducing the impact of the negative effect, are evaluated up to revealing the decrease of a desired output. The positive effect which is impaired by a modification of the chosen parameter, as well as its operative time and space, are then identified along the logical block. The mismatching behaviours, faced as a result of increasing/decreasing the chosen control parameter, constitute the core formulation of the physical contradiction. The cognitive process holds therefore the purpose, as in ARIZ step 3.1, to individuate the opportunities of introducing an X-element, capable of removing the negative effect and providing benefits at the maximum extent, as figured out by the Ideal Final Result. If any parameter is individuated, whose variation provides benefits with no drawback, the procedure suggests to perform such modification and to reformulate the problem, thus restarting from the IS block (line 11). If it is not possible to identify a control parameter leading to the physical contradiction, the algorithm guides the user through the RE (line 12) or PR (line 13) blocks for a further characterization of the undesired effect.

3.3.4 The logical block Performance (PE block)

The block Performance is addressed to reformulate the system under investigation or the undesired effect. It is accessed whenever the user recognizes any kind of under-performance of the system or the need for introducing a new function. First, it is required to define a performance to be enhanced or satisfied by the implementation of the new function and to explain the motivations for the increase of the performance itself. The user is then asked to individuate who or what would perceive the benefits of the improvements, who or what doesn't allow the enhancements in the current technical system. If any of the previously identified items is viable to be modified, specific directions are suggested to the user and he is directed back to the IS block (line 14). Besides, emerging requests of modifications of the production process are directed towards the PR block (line 15). Other situations bring to formulate the negative effect of the system in terms of an unsatisfactory performance and consequently to follow the NE block (line 16).

3.3.5 The logical block Resources (RE block)

The excessive amount of resources spent by a technical system is typically considered just as an administrative drawback due to the fulfilment of requirements. This logical block investigates the resources needed by the system, classifying them in terms of space, time, information, material and energy. When the designer judges the direct costs as the most critical resource spent during the system lifecycle, the algorithm guides him towards the CO block (line 17) for analyzing the reasons of the high expenditures. Among the amounts of resources spent, the user is asked to determine those representing the most challenging criticalities and whether this issue can be assumed as the negative effect to be targeted (NE block, line 18).

3.3.6 The logical block Costs (CO block)

In TRIZ terms costs reduction must be addressed by leveraging the internal resources of the system. The logical block is aimed at classifying what provokes high costs for the system use, production or maintenance. The resources responsible of the high costs are clustered with the same criteria of the RE block. The questioning procedure directs the designer towards the RE block (line 19) if the costs concern the user of the system, whilst it guides towards the PR block (line 20) if the expenditures characterize the production process.

3.3.7 The logical block Process (PR block)

This block investigates criticalities about the production process. The scope of the PR block is to reformulate the negative effect and the element that provokes it (line 21), downstream the individuation of the critical issues concerning the production of the system. Since the focus of the investigation could be moved from the product to the design, manufacturing and assembling phases, the questions let the user change even the system to be analyzed (line 22).

4 Testing activity and discussion

The present section first describes the organization of the testing campaign set up to validate the proposed algorithm, implemented as a web application. Then, the results of the experimental activity are discussed in terms of efficiency, estimating the effectiveness of the system through a comparison of the outputs with previous experiences and its robustness, by evaluating the repeatability of the outcomes.

4.1 Test group and test cases

The proposed dialogue-based algorithm has been tested by 30 Master Degree students in Mechanical Engineering at University of Florence and at Politecnico di Milano. All these students had received 20 lecture hours about TRIZ fundamentals, with different proficiency results. Further tests have been carried out by 4 PhD students and a postdoctoral research fellow in Mechanical Engineering with no TRIZ background, in order to appreciate differences and similarities according to different level of competences. The tests were run in laboratories where each person, in at most 90 minutes, had to analyze one of three real industrial problems (A, B, C) chosen for their different characteristics, in order to evaluate the capability of the algorithm in driving the user towards the logical blocks, which was considered the most proper for each case study. Although each problem structure depends on the user interpretation, the most accurate problem model would imply the identification of an appropriate physical contradiction; besides, it is expected that at least people should model case A as a resources reduction problem, case B as a negative effect and case C as the implementation of a new performance or the improvement of an existing one. Case A has been faced by 11 students and 2 PhD students; Case B was tested by 13 students and 1 PhD student; finally Case C was examined by 6 students, 1 PhD Student and 1 post-doctoral research fellow.

4.2 Overview of the results and discussion

The results of the problem situation analysis have been evaluated according to the following metrics:

- a good result is characterized by a precise description of the problem, as well as by an appropriate set of features and elements, viable to lead to a suitable information retrieval;

- a satisfactory result is characterized by a global representation of the problem under investigation, with an almost complete description of its main characteristics; the available information about the problem gives preliminary criteria for information gathering;
- an unsatisfactory result relates to a poor description of the problem, rich of misinterpretations and with no useful information capable to enlarge the potential solution space.

Fig. 2 provides an overall outlook of the results achieved by the Master Degree Students from both the Universities; PhD students were considered separately.

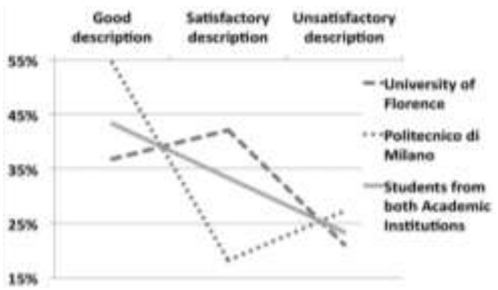

Fig. 2. Results of the application of the algorithm at Politecnico di Milano and University of Florence.

In the assigned time, more than 60% of the Master Degree Students were driven towards one of the final nodes of the algorithm, as well as 23 out of 30 (76,6 %) gave at least a satisfactory description of the problem situation (Fig. 2, continuous line). However, just a small part of them (13,3% of the grand total) formulated a complete model of contradiction.

A comparison between the Master Degree students from both the academic institutions does not highlight noticeable differences, since 75% of them obtained positive results (approximately 80% in Florence and 70% in Milan), while students from Politecnico di Milano totally got better quality results (good 54%; satisfactory, 18%) than their mates from University of Florence (good 37%; satisfactory 42%). The students who properly formulated a contradiction through the dialogue-based system achieved the best results in terms of abstraction according to the Hill Model: they got to the description of a physical contradiction and also identified the main characteristics that the solution should have in order to solve the problem. Consistently with the problem solving models proposed in section 3.2 the algorithm has proved to be successful in stimulating the user in refining the problem under investigation, allowing to focus on different hierarchical levels of the system, thus moving upwards or downwards in the System Operator (more than 50% of the students have modified their initial definition of “system”).

The convergent problem solving process described by the Funnel Model emerges by analyzing the body of results produced within this testing activity: the students frequently converged towards the same problem model, even if in many cases, this hasn’t resulted sufficient for formulating an appropriate contradiction.

By thoroughly investigating the procedures carried out by the students that obtained good results, it emerged that many of them achieved great benefits by changing the definition of the “technical system”: they progressively changed the scope of the problem by identifying the right detail level and the critical features to be improved or to be removed. It is noticeable that all these students, regardless of the test case under analysis, considered the problem related to unsatisfactory performances of the technical system. The iteration of the procedure gave them a different perspective of the whole problem and by means of problem reformulation one third of them identified a critical contradiction for the problem solution. Besides, the students of this group that didn’t get to the definition of a contradiction leveraged their knowledge building an appropriate description viable for a profitable information retrieval. Most of these students (about 85%) came indeed to one of the final nodes of the procedure with positive conclusions.

On the other hand, the students that didn’t succeed in obtaining valuable results often followed an odd logic since they experienced some difficulties in distinguishing between elements/components of the system and their parameters. About half of them tried to force the procedure towards the direction of a solution they had intuitively elaborated, rather than using the dialogue based system as a guiding tool to gradually explore the characteristics of the problem under investigation. Differently from their colleagues who obtained positive result, 57% of these students didn’t get to the end of the procedure, without taking therefore advantages from the refinement of the definition of the system.

It is equally important to verify whether the goal of approaching the problem with the right branch of the procedure has been met or not. By considering the sequence of steps that all the students went through, a simple analysis of Pearson’s correlation remarked that the students, regardless their success in exploiting the procedure, followed very similar paths of analysis.

About the potential differences in the solving path followed by more specialized people, the group formed by the PhD students and the postdoctoral research fellow produced only good or satisfactory results. In three cases they got to a good formulation of a contradiction, thus abstracting the problem and identifying the main features of the solution. In the remaining two cases the description of the problem was just satisfactory, but useful to perform a relevant information search.

The same test group of MS students has been involved also in manual tests without any computer support, but with the possibility to access their own books and the slides of the 20 hours course they had attended. The same assignments mentioned in section 4.1 have been submitted, even if with a different order.

By comparing the overall outcomes of the manual tests with those obtained through the proposed dialogue based system, the share of students showing negative results drops from roughly 35% to about 27%. However, an in-depth analysis of the results highlights that students that had valuably employed problem solving methods or tools by themselves (approximately 46% of the grand total) didn't obtain particular benefits in approaching the situation by means of the dialogue-based system. On the contrary, the greatest benefits of the procedure emerge with those students that had previously showed more limited skills in the employment of systematic problem solving techniques. In fact, more than two thirds of them described the problem in a more appropriate way than they had been capable without computer support.

5. Conclusions and future activities

The present paper proposes a model for computer-aided systematic problem solving, which has been adopted as a reference for the development of an original algorithm aimed at guiding designers, even without any TRIZ background, in the generation of inventive conceptual solutions. The algorithm has been implemented in a prototype web application already tested with MS and PhD students, obtaining positive results especially with the students with poorer systematic problem solving skills.

The tests performed so far have demonstrated that the proposed system is suitable to combine several expected benefits of the most acknowledged problem solving techniques. First, cognitive capabilities are enhanced by soliciting the analysis of the problem from different perspectives, thus overcoming psychological inertia as typically addressed by TRIZ System Operator. Indeed, while the overall results of the test have been satisfactory, the proposed algorithm needs to be improved in terms of supporting the identification of a proper model of contradiction.

The system is also structured in order to elicit lacks of knowledge by the user, either in terms of limited understanding of the mechanism originating the problem, or missing physical/chemical effects suitable to deliver a certain function. Such knowledge lacks will be used as inputs for a patent-mining tool capable to extract relevant information from patent texts within or even outside the problem domain. The complete system will be tested within a project of the EraSME EU Programme, by involving a number of Small and Medium Enterprises from Italy and Spain.

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