Solving Lab: Inventive problem-solving laboratory

Carine Frérard[1], Vincent Lenaerts[1], Bernard Rausin[1] and Xavier Lepot[2]

[1] HELMo Gramme, 4000 Liège, Belgium
[2] xFIVE scrl, 7890 Ellezelles, Belgium
lncs@springer.com

Abstract. The polyvalent industrial engineers studying in HELMo Gramme school develop their skills on practical cases from companies since always in an active pedagogy frame. The encounter of some professors with TRIZ theory led to the idea of creating a powerful pedagogical lever. Combined with the desire to develop entrepreneurship in learning activities, HELMo Gramme sets up the Solving Lab project: a problem-solving laboratory serving the surrounding ecosystem (enterprises, students, alumni, research center, public entities ...). It is both an educational tool that will reinforce the integration of learning outcomes for students and professionals, and a practical tool that will reinforce the integration of creative scientific methods in regional enterprises (especially SME). This altogether pedagogical and practical tool will rely on specialized TRIZ partners such as xFIVE to develop methodological tools, to create, in addition to an educational value, a usable value for the society.

Keywords: Education initiative, SME's case study, TRIZ based methodology.

1 Introduction

1.1 Origin of the Solving Lab idea

For more than 100 years, HELMo Gramme school forms polyvalent engineers and has always had close links with regional companies, multinationals and SMEs. In order to maintain this proximity, since 2013, teachers have been sensitized to the entrepreneurial spirit through a training program that includes a section devoted to creativity. This is how TRIZ entered the school and progressively made its way into project courses, with the support of xFIVE. Thanks to this methodology, cases submitted by companies and used in school program have found unexpected and innovative solutions. From this came the idea of formalizing the system and providing an economic model that encourages companies to entrust their problems and the implementation of the inventive solutions that would be developed by HELMO engineering students. The concept “Solving Lab” was born.

1.2 Objectives of the Solving Lab project

The sparkling idea of the Solving Lab was to develop abilities of students in engineering to solve technical complex problems with systematic creativity. By maturing the project, we wanted to extend its objectives to make it a real societal tool. The Solving Lab presents now several complementary aspects which participate together to maximize the value for society in a broad sense perspective:

- **Create powerful problem-solving methodological tools**: work out a creative, practical and evolutionary tool for solving complex problems which is inspired by TRIZ in combination with other user-oriented and agile approaches (design thinking, lean start-up, agile, etc.) thanks to partnerships with the other actors of the regional creative economy. The particularity of this tool is to be in permanent co-construction because every new problem, every new collaboration comes to feed the source of solutions as well as the way of exploring problems.
- **Amplify active pedagogy:** adapt the pedagogy of the school so that its learning device integrates the problem-solving service offered to companies, with initiatives as coach teacher, inverted class, e-learning, integrated assessment, transversal work between courses and years, organization of workshops, etc.
- **Feeding research programs**: collect the ideas and the immature solutions to develop applied research programs.
- **Connect with ecosystem**: communicate and interact in a permanent way with the ecosystem of companies to collect the "problems" to be solved, to identify them correctly and once the found solution, to implement it in the company and so to become a vector of innovation.
- **Create added value**: use an innovative business model to value the results obtained. This model takes into account all the types of gains, not just financial, to maximize the value for the whole community. For companies, it presents the advantage that they will pay only if the results are satisfactory and applicable.
- **Support permanent education**: use the method developed with companies to serve as a basis for continuing education and coaching

2 How Solving Lab works

2.1 A stepwise Approach

The Solving Lab is a device that addresses all stakeholders in the regional ecosystem. It allows them to propose concrete problems to its pedagogical device in order to solve them in a creative way thanks to methodological tools based on TRIZ and to different partners. By passing through the Solving Lab, problems are transformed into concrete, creative and applicable solutions. This is working in a stepwise approach as illustrated by fig. 1.

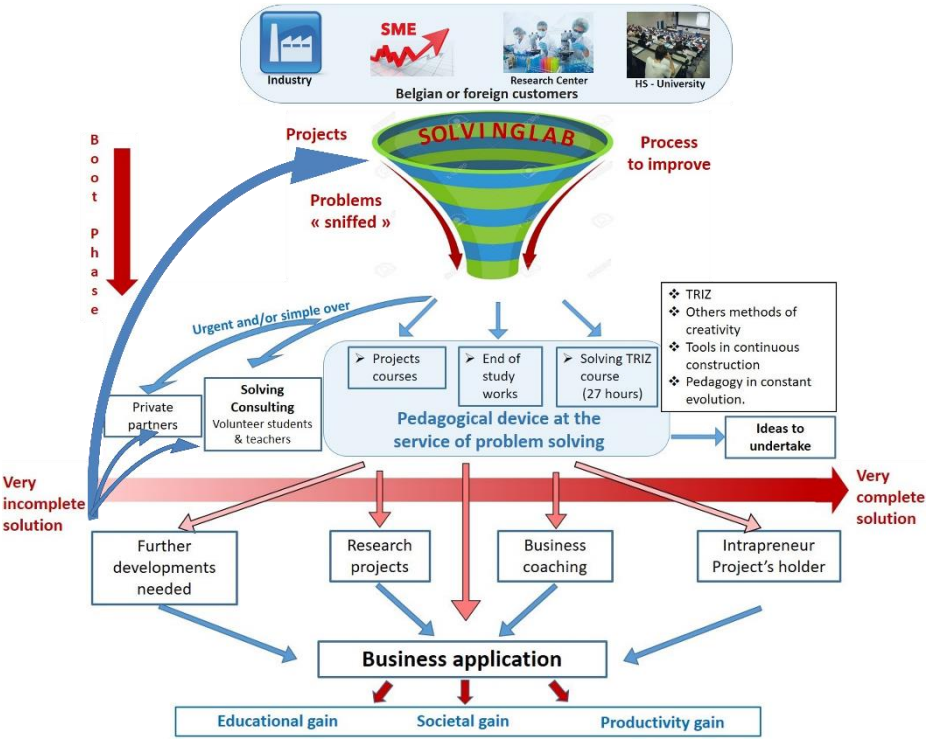

Fig. 1. Global overview of Solving Lab

Step 1: Collect problems. It consists in gleaning from our private and academic partners a reservoir of cases to be treated by the Solving Lab. These can be clearly identified or simply suspected problems, processes to be improved, suggestions for improvements identified in an operational excellence management process... Our network of partners is under construction and brings together professional federations, clusters, research centers, competence centers, competitiveness clusters, as well as service enterprises as xFIVE. These partners will also relay the service proposal to their own network of companies.

Step 2: Fix the rules. This is to settle the relationship through which problem owners in search of inventive solutions and Solving Lab will be linked. To determine the value in the broad sense of this device, it is indeed necessary that in the boot phase commitments are made by each of them, as to the use of the outputs that will be produced by the Solving Lab. The basic principle is to leave as much latitude as possible to each party but in the frame of a convention. The company at the entrance is only committed to entrust the problem without any form of confidentiality. It also recognizes that the solutions developed by the Solving Lab belong to the School. If one of the solutions delivered by the Solving Lab corresponds to the expectations of the company and is ready to apply, the company commits to valorize it financially or in another form. For

example, by the hiring of an intrapreneur, by a contribution to the financing of applied research, ... If on the other hand at the end of the passage in the device the company is not ready to exploit the output which it is proposed, the company leaves the School free to exploit it and is indebted to it for nothing. The partners mentioned above also contribute to co-build the economic model that governs this device in order to maintain a real win-win relationship between both parties.

Step 3: Switch to the educational device. A responsible is entitled for evaluating the problems collected in terms of complexity but also in terms of their educational potential to dispatch the submitted issues in the different courses and levels. The role of this responsible (someone with experience and pragmatism) is essential because it ensures the technical link but also the efficient and practical use of methodologies as TRIZ by the device. The treatment of the problem by students can indeed take different forms:

- Project courses (machine building, industrial chemistry, ...) where the practical work in group is privileged to implement the theoretical skills acquired
- Graduation work where it is the individual relationship through a project between a student and a company that is targeted;
- The Solving TRIZ course which aims to teach students TRIZ method and to practice it on concrete cases but without going as far as practical realization;
- Through an extra-curricular structure, named Solving Consulting, that makes it possible to put volunteer students supervised by teachers to solve problems that may be simpler and more urgent.

The duration of this stage is approximately one year. Urgent problems are redirected to private partners. To carry out this project pedagogically, an Academic Guarantor is necessary to ensure the smooth integration of the Solving Lab within all the academic bodies. In concrete terms, he ensures the formalization of the Solving Lab methods through shared tools and in constant co-construction so that the practice spreads harmoniously within the school and influences more teachers and subjects. He also strives to change pedagogical practices towards more interactivity between teachers and students, between students of different years and between teachers.

Step 4: Valorization of the outputs. At the end of the passage in the pedagogical system, the solutions are either complete and therefore directly applicable in the company, or incomplete and require further developments. In the first case the client company which is satisfied with the deliverable will pay an estimated amount on the basis of criteria previously fixed in the bilateral agreement. The company can also decide to hire one of the students carrying the project and make it an intrapreneur. Depending on the case, it is also possible that in the end, the students who worked to solve the problem will seize the solutions and exploit them themselves as entrepreneurs. In the second case (unsatisfactory results), the research center of the School and its interface to the economic world supports the follow-up by planning to take over the problem in an applied research program of which the client company may or may not be a partner. Subsidized programs can also allow through a personalized approach of coaching or

consultancy to continue the adaptation in practice of the solution that was developed. A second passage in the device is also possible. In all cases, there is a triple added value: educational, societal and economic.

3 Pedagogical aspects

At the pedagogical level, the Solving Lab has two important aspects that must be distinguished even if they both serve the same purpose of preparing our future engineers for professional life as well as possible.

3.1 Develop engineering skills

The Solving Lab will support future engineers to acquire a technical maturity and know how to exploit it differently thanks to TRIZ. Indeed, learning and mastering the TRIZ method offers a new vision of the theoretical technical skills acquired during their Bachelor years. The Solving TRIZ course intervenes in BAC 3, once the students have a sufficient baggage to understand the laws of evolution, and they are able to exercise in the most efficient way possible the tools of TRIZ, by combining altogether inventive problem-solving and pragmatic implementation. At the end of the bachelor's degree, bringing a method that links all the learning outcomes and thus offers a global vision of the applications of their training can only bring more meaning to the importance of the multidisciplinary approach advocated by our school. Master's years are therefore a real exercise ground for theoretical knowledge they acquired before.

3.2 Start a project and develop entrepreneurial attitudes

Once the TRIZ method has been learned and practiced on paper in BAC 3, the project is first implemented in Master 1 through project courses including the "machine building" where they use TRIZ in groups, coached by a teacher on concrete cases submitted by companies up to the realization of demonstrator. They are thus in the situation of service provider facing a customer with his wishes, specifications and other constraints and are therefore led to exercise their creativity through TRIZ, their initiative, their sense of responsibility, their teamwork spirit, perseverance and self-confidence. In Master 2, the curriculum provides for the completion of an individual work graduation also on behalf of a client and the student has 3 months full-time immersed in the company to solve the problem that was submitted to him in very concrete way. They always have a pedagogical supervision from their tutor. In addition, for students who want to go further in the entrepreneurial process and in the application of inventive solutions for companies, Solving Consulting allows them to practice outside the curriculum.

4 An innovative valorization Model

Traditionally, in Belgium anyway, the links between companies and High Schools or Universities within the framework of the educational system are not valorized financially. It is an exchange considered as fair by the parties: one party provides case studies and gets free labor and the other party uses these cases for educational purposes to the benefit of students. This model neglects the overall value which is generated by the exchange and can benefit the whole community: creativity, inventiveness and innovation. Too often promising Master projects return to the bottom of a drawer just because the priorities of the sponsoring company have changed along the way. The model of the Solving Lab aims to avoid this kind of situation by leaving the lead in the School, in case of lack of interest of the company, to initiate an applied research or to develop other valorization possibilities as spin-off.

Moreover, we must be aware that the Solving Lab must respect the academic pace which is slower than that of the economic world. In case of urgent problem, it is obviously not this device that the company must address (that is also the reason why the Solving Lab is working in partnership with private innovation consulting enterprises). There are, however, many cases where processes are perfectible or there are minor problems that are not tackled for different reasons (as the fear of the cost that it would generate). These are the ideal cases for the Solving Lab.

5 Example of a solved case: EPUR

5.1 The company

Created in 1996, EPUR is specialized in the treatment of domestic and industrial wastewater by biological treatment. All of its wastewater treatment plants are designed to minimize frequencies of draining. Their design makes it easy to replace wearing parts even when they are immersed. EPUR SA is a major player in the landscape of individual purification units in Belgium but also for export. It is present in many countries from France to Oceania through the overseas territories.

5.2 The problem

The treatment plants are composed of concrete vats that must be drilled to allow the passage of the equipment. The drilling of some of these orifices must be done by workers. Initially, they manipulated a core drill sliding around a fixed mast. The displacement of tanks up to 10 tons up to the core was done by forklift. The working conditions of the workers were therefore not optimal both in terms of safety and reliability (see fig. 2).
This problem has been used as case study for students in Master 1, with as main goal to confront them to TRIZ approach for problem solving.

Fig. 2. drilling operation (before the project)

Different problems were identified, by the students:

- The safety of the worker was not assured because he was working on a ladder;
- The precision of the drilling was insufficient;
- The positioning of the tank (weighing from 5 to 10 tons) by the forklift was long, difficult and inappropriate;
- The various drilling diameters required frequent and inconvenient changes in the core drill head;
- Dirty water was falling on the floor which made the work area dirty and slippery.

5.3 Problem-solving

The teachers of the "Machine Design & Building" course of Master 1 want that their students achieve different goals through this case study:

- Learn how to design a machine from a set of specifications including providing detailed plans and calculation notes for its various components.

- Develop within the framework of this project, organizational and group management skills. Stimulate the necessary entrepreneurial qualities, such as creativity, self-confidence, initiative, team spirit, sense of responsibility, and perseverance.
- Make, if possible, a prototype of the machine or some of its components, using conventional or new execution techniques (as 3D printing).
- Analyze, synthesize, evaluate and present the work done through the writing of a report and its oral defense by the group.

The EPUR project presented a sufficient complexity and fit well these objectives. 5 groups of 5 students have looked into this one problem using the TRIZ method.

5.4 Use of TRIZ in this problem-solving

Because we wanted to put them in contact with inventive problem solving and make them "learning by doing", students were asked to use 3 tools within all the TRIZ tools [1][2][3]:

- The multi-screen matrix
- The Final Ideal Result
- Technical contradictions and matrix of inventive principles.

For example, here after is illustrated in Figure 3 the use of this latest tool applied to the positioning of the drill relative to the tank, considered as action parameter. In its initial operation the core drill is considered fixed. The corresponding physical contradiction is therefore the fully mobile core drill and the fixed vessel.

In case n°1 illustrated in fig.3, the evaluation parameters are the speed and ease of use:

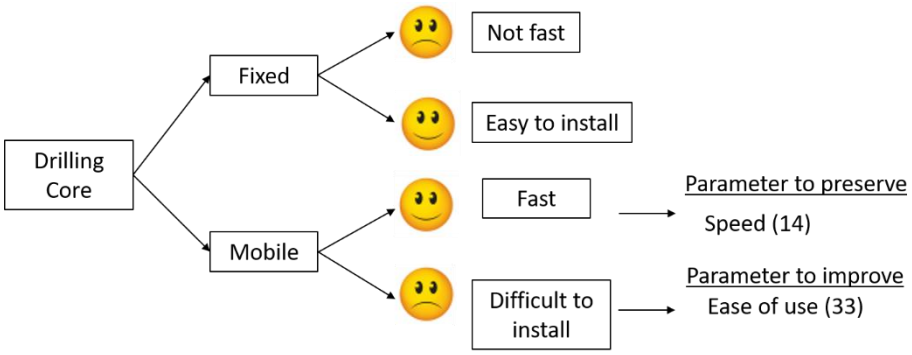

Fig. 3. Contradiction n°1

By introducing this set of generic parameters (9,33) in the matrix of inventive principles [4], one gets the following inventive principles and the corresponding ideas found by the students:

- Principle 32: change of color => Idea: none

- Principle 28: mechanics substitution => Idea: magnetically adjusted core drill
- Principle 13: inversion => Idea: Rotation of the core drill, pneumatically sucking instead of mechanically fix (cupping to adhere to the tank)
- Principle 12: equipotentiality => Idea: the tank does not move, and it is the drill that can take all positions from where to use a crane and allow the rotation of the drill.

5.5 An innovative solution has been developed by one of the team

Based on these different tools, numerous solutions were proposed by the students. One of them has been further developed: a machine suspended from the crane of the work-shop which is fixed on the tank by means of suckers (see figure 4). A small prototype of suction cups has been made by the students to validate the principle because the suction system exists for the flat walls, but not for the curved walls.

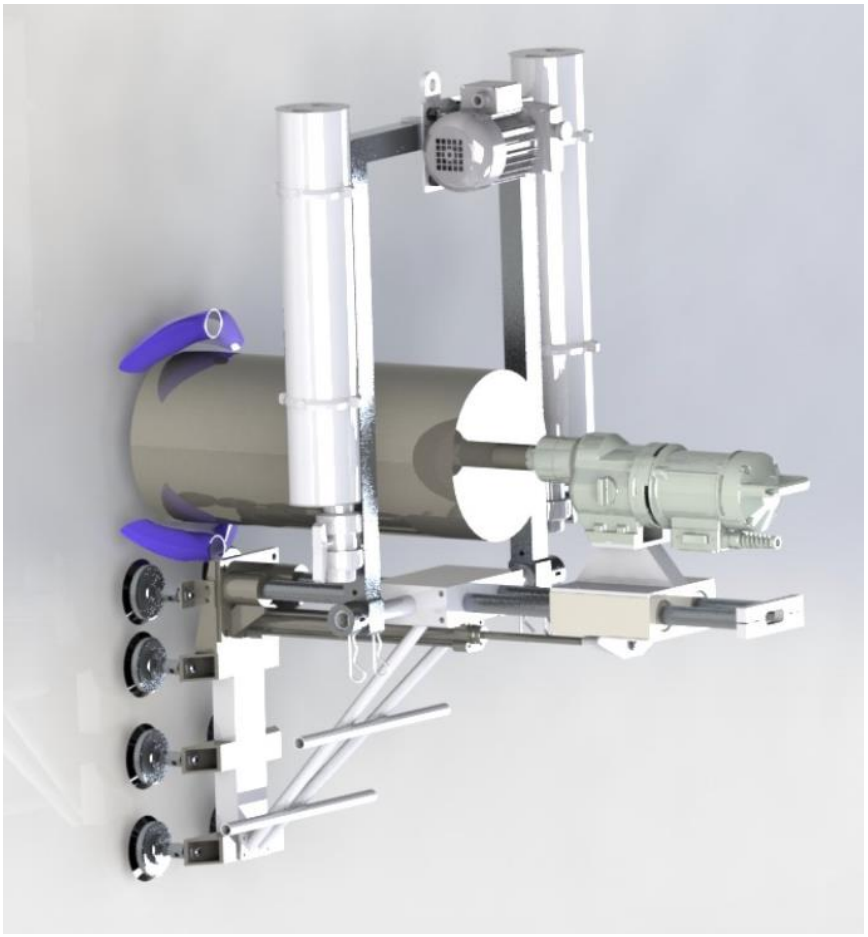

Fig. 4. Model of vacuum-fixed drill

In this case, EPUR was convinced by the presentation of the solution by the students. Not being in a hurry, the company decided to put the project back into the system of Solving Lab and asked for a prototype of the machine to be built in the next year.

On the next academic year, the students of the mechanical orientation of Master 2 took it as a project. A model at scale 1/5, printed in 3D was first made by the students. This sequencing made it possible to produce a functional machine with a minimum of development time to correspond as much as possible to the expectations of EPUR.

The parts constituting the machine were ordered and assembled by the students. The prototype has since been used by the company EPUR (see figure 5).

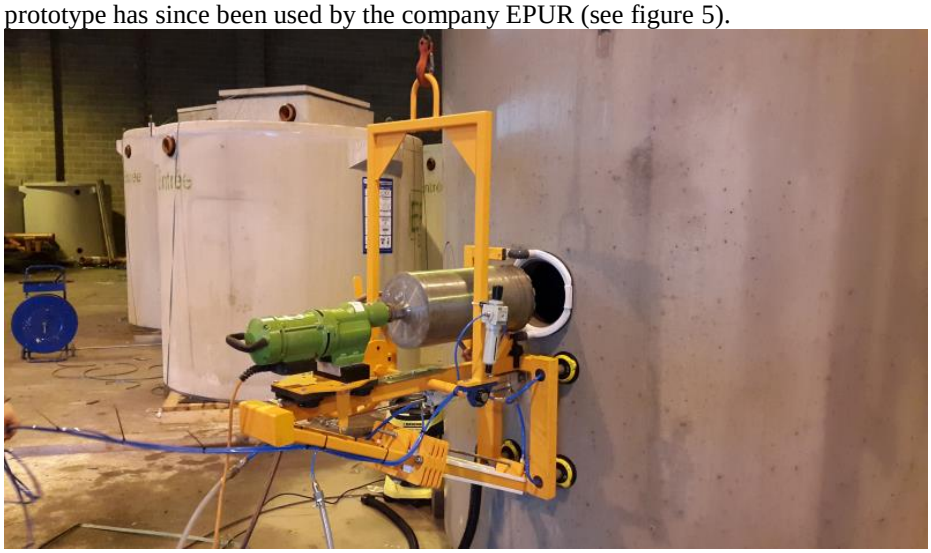

Fig. 5. the EPUR drilling prototype

6 Solving Lab: a transposable experience

6.1 Pedagogical Tools

The pedagogical added value of the Solving Lab corresponds to a need for higher education: to bring future graduates closer to the world of business while bringing creativity and innovation in their pedagogical journey. It is therefore important in the process to provide educational tools that will allow other schools, teachers to start a similar approach while adapting to their specificities. A toolbox will be developed for this purpose. Our intention is to make this toolbox clear, structured, accessible and obvious but also attractive, based on examples and storytelling. This communication must be as innovative as the method it promotes. Thus, it will take the form of a web platform to disseminate the method that will be in perpetual evolution. Ideally, this should lead to the creation of a community of practice that is active in the inventive problem-solving

of high schools. On the training side, the current practical tool is the MOOC, which will have to be adapted to different audiences: students, teachers, industrials, colleagues from other schools, researchers, etc.). It will be accompanied by practical work because the acquisition of the method can be done only based on its experimentation on concrete cases. The success of this phase will depend on the user-friendliness of the toolbox and the communication media to highlight them.

6.2 Alumni network as effect multiplier

HELMo Gramme benefits from a community of graduates who are very attached to the institute where they made their studies. They are generally receptive to initiatives taken to bring engineering education closer to professional practice. The Solving Lab is therefore a welcome hyphen that can, in addition, bring added value to the companies in which they are active. We therefore rely on this proximity to develop in the Solving Lab modules continuing training initiation to inventive methods inspired by TRIZ. This a way to expand the community of practice, spread creativity and innovation within companies, while enhancing the versatile side of training. This approach can have a multiplier effect if the training masters who supervise the ITWs are themselves convinced, trained and spin-off factors in the business world.

7 Conclusion

The Solving Lab initiative is innovative in its approach and generates added economical, educational and societal values. It is a propeller of innovations that will fertilize the regional business ecosystem.

The Solving Lab reinforces the link between the business world and that of higher education. It is located at the crossroads of each other's concerns in a changing world.

Companies are more than ever in search of competitiveness and innovation. Even if the Solving Lab works with an academic pace which is slower than the business rhythm, it provides a functional support. And the Solving Lab contribute to make the future graduates of HELMO more inventive and entrepreneurial, which is desperately needed by companies.

For its part, education must get closer to the field, the real world to which it propels its future graduates and must take full measure of the place it occupies in the ecosystem that surrounds it.

Using inventive methods for problem-solving as TRIZ and relying on a strong network of partners creates real cross-fertilization and brings value in the broadest sense.

The experience of HELMo Gramme and his Solving Lab is under way and his model is being tested. It will be evaluated to a three-year term from now on to see if it keeps this promise.

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