Education and Training of
Creative Problem Solving Thinking with TRIZ/USIT

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Abstract

Experiences of teaching under-graduate students and training industrial engineers on how to think creatively in problem solving are reported. The contents are based on the TRIZ methodology but have been further reorganized and unified into USIT (Unified Structured Inventive Thinking) for easier to learn and apply. Case studies, published by engineers in technologies and obtained by students for everyday-life problems, are found useful in both teaching/training situations.

Keywords

TRIZ, USIT, Teaching, Problem Solving Methodology, Case Studies

1 INTRODUCTION

The capability of creative problem solving has been regarded long as the power of talented people and the source of innovations. But how to think creatively in problem solving, especially in technological fields, has been difficult to explain, teach, and train, because the ways of thinking are not well structured. TRIZ, i.e., Theory of Inventive Problem Solving originally developed by Genrich Altshuller [1] in former USSR, has given a structured methodology for creative problem solving in technologies and other fields as well.

Nevertheless, the penetration of TRIZ into industrial engineers and university students has not been so wide and so fast in the western countries as was expected by people who knew the value of TRIZ. The methodology of TRIZ itself needs to be adapted and reorganized for easier learning and application, some people including the author has been advocating [2].

USIT (Unified Structured Inventive Thinking) was developed by Ed Sickafus [3] under some influence of TRIZ, in a form of simplified and unified process of creative problem solving in technologies. The present author has adopted USIT in Japan since 1999 and reorganized all the TRIZ solution generation methods into the new USIT Operators [4] and found the Six-Box Scheme as a new paradigm for creative problem solving [5, 6].

The present author has about 10 years of experiences of teaching and training TRIZ/USIT to industrial engineers and university students. Many articles published in his public Web site "TRIZ Home Page in Japan" [7] both in Japanese and in English have been serving for giving wider and prior understanding of TRIZ/USIT and also for publishing the results of such teaching/training.

His training course of creative problem solving thinking with USIT (and with some TRIZ) has already been established for industrial engineers in the form of intensive 2 day seminar with lectures and group work on real problems [8]. This training in such a short term is possible because of the engineers' high motivation and background knowledge in technologies and also the unified simple structure of USIT.

Education of creative problem solving thinking to university undergraduate students, however, needs much longer time. Understanding of technologies in general terms, like systems, attributes, functions, processes, causes and effects, and also understanding of physical/chemical mechanism behind the problems take much time for them to learn. The lack of experiences of technological development, manufacturing process, and patent writing/reading, competition with other companies, etc. also make the students difficult to learn and even difficult to motivate to learn the methodologies for creative problem solving thinking.

In this situation, in Osaka Gakuin University, I have established and conducted three steps of classes, namely a lecture class for 2nd year students, a group-training seminar class for 3rd year students, and a thesis-writing seminar crass for 4th year students [9]. For these few years a number of students passed these three steps of classes and accomplished their thesis works of solving every-day life problems.

Both in the training of engineers and in the education of students, good case study examples are found the key materials for easier and better understanding. Case studies of technological problems solved by engineers and of everyday-life problems solved by students serve for both engineers and students to better understand the methodology.

In the following sections, I will describe about the USIT methodology briefly by example of a student's case study, and then the way of training engineers in 2-day seminars, and finally the way of educating undergraduate students in the three step classes.

2 USIT METHODOLOGY ILLUSTRATED BY AN EVERY-DAY LIFE CASE STUDY

2.1 The Six-Box Scheme of USIT

It is found important to draw the basic scheme of problem solving in the form of 'data flow diagram', in which boxes contain the information requested/resulted at initial, intermediate, and final stages and are connected by arrows showing the conversion processes [10, 11]. The scheme in this form is known from information science to be more basic and robust than the one drawn in the flowchart, where boxes contain the processes and are linked with arrows to show the sequence and logic of their processing.

The basic scheme of problem solving with USIT is illustrated in Fig. 1 in the form of data flow diagram. This scheme is named the 'Six-Box Scheme', in contrast to the ordinary 'Four-Box Scheme' of TRIZ and science & technology in general.

On the basis of the Four-Box Scheme, a huge number of methods have been accumulated in TRIZ [12] and in all the fields of science and technologies. Such methods serve as the templates of generalized problems and

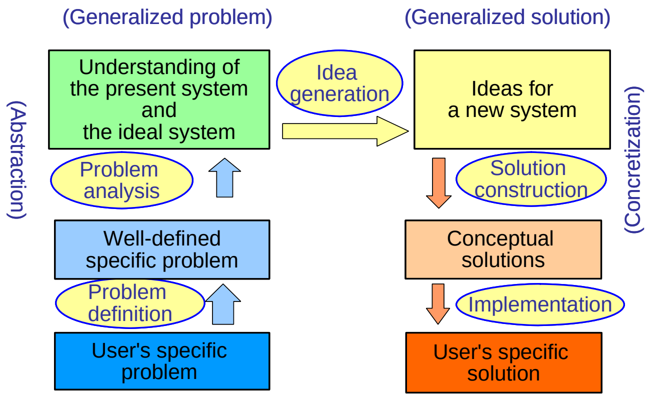

Fig. 1. Six-Box Scheme of Creative Problem Solving in USIT

generalized solutions in the Four Box Scheme. Since different methods focus on different aspects of problems, a number of methods are often necessary for analyzing and solving a problem. Thus the nature of the information required in the box of generalized problem needs to be described differently for a number of methods to be applied to one problem.

In the Six-Box Scheme in USIT [13], on the other hand, a standard set of methods are applied in the problem definition and problem analysis. The generalized problem in the Four-Box Scheme is now described as the understanding of the present system and the ideal system. The understanding of the present system should be formed in terms of space, time, objects (or components), attributes, and functions, and hence should clarify the mechanism of the system and the plausible root causes of the problem. The understanding of the ideal system should be formed in the image and described in terms of desired behaviours and desired properties.

In USIT, the ideas for a new system may be small and fragmentary. They can be obtained in various ways, sometimes spontaneously stimulated during the analysis process and sometimes by applying USIT Operators systematically. Around such a small core idea, solutions of the problem should be built up on the basis of general or specialty capability of technology, often supported by knowledge bases (including patent databases). Then, after finishing the USIT process, the solutions need to be implemented into real products, processes, etc.

For performing the Six-Box Scheme, USIT has its full procedure [13], which may be represented in a compact flowchart. However, there can be different ways for performing the same Scheme. For example, time characteristic analysis (e.g., process analysis) may be carried out either before or after the functional analysis, and different ways of functional analysis are applicable. With this fact in mind, a case study of applying USIT is demonstrated below.

2.2 A USIT Case Study: How to Fix the String Shorter Than the Needle

The Case Study shown here is based on the thesis work carried out by Tsubasa Shimoda, 2006 [13, 14]. In my seminar class, Shimoda being assisted with three other students worked to solve this everyday life problem, under the guidance of the present author. The process of thinking and problem solving went back and forth actually, but is described here along a standard order, for the sake of clarity.

Problem definition

By the discussion of the student group, the items shown in the following slide (Fig. 2) are revealed.

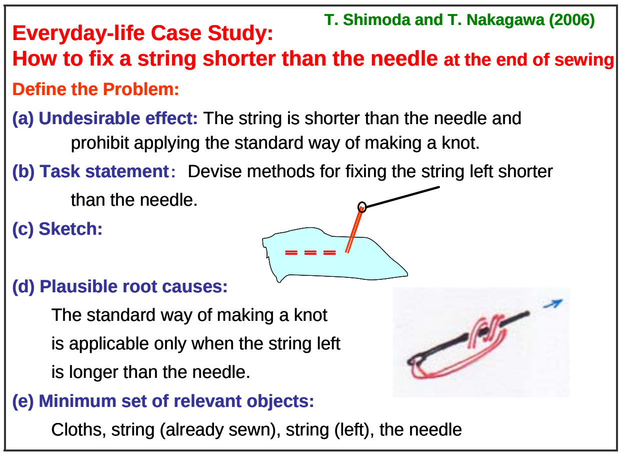

Fig. 2. Definition of problem [13]

Problem analysis

The problem is analyzed with a standard set of methods. First the present system is analyzed in terms of objects, attributes, and functions, and also in time and space characteristics (See Fig. 3). Survey of known solutions at this stage is also useful. Then the ideal solution is depicted (See Fig. 4) .

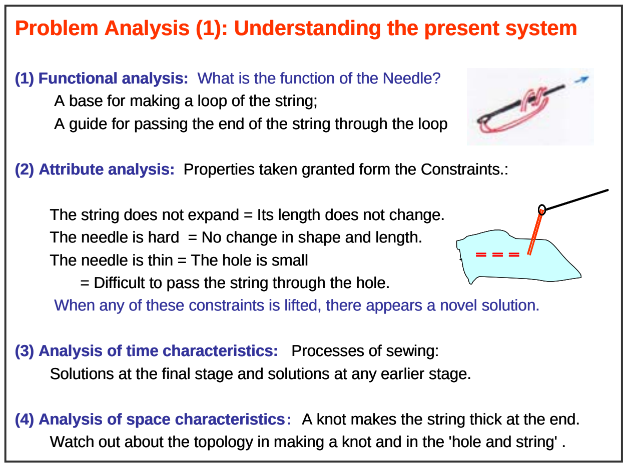

Fig. 3. Problem analysis (1) [13]

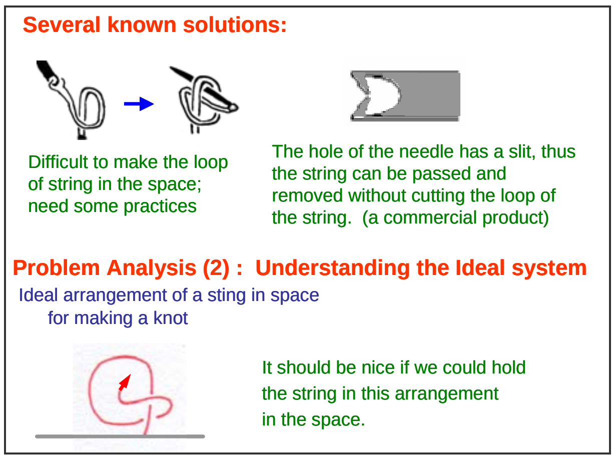

Fig. 4. Survey of known solutions and the image of the ideal system [13]

Solution generation

In Fig. 5 two cases of solution generation are described.

One case is derived from the idea that we should support the string just in the form of ideal solution by using some

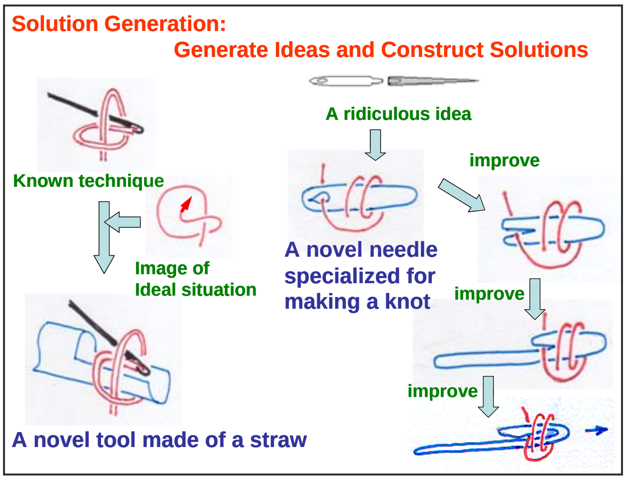

Fig. 5. Idea generation and solution building [13]

small tool. A straw cut in the form of a groove has been built as the solution. The second case started with the idea of making the needle dividable at the end of sewing. This has stimulated the idea of a needle specialized for making the knot only by giving up the function of sewing. This idea has been improved with small steps into the solution of a hair-pin shaped tool specialized for making a knot.

As you see, the problem is defined, analysed, and solved step by step as guided by the Six-Box Scheme to derive novel and practical solution concepts. These solutions can be realized easily and seem to be very useful.

3 TRAINING OF ENGINEERS: 2-DAY USIT TRAINING

For penetrating TRIZ and USIT, I have been giving many presentations, lectures, and seminars, and published many papers and articles in the Web and in some journals, and published textbooks in Japanese translation. These are mostly addressed to engineers in industries.

For training engineers, I have been conducting 3-day and 2-day training seminars of USIT since 1999 [8]. The training seminars are carried out both under in-house and open multi-company situations, with the contents essentially the same. The USIT training seminar delivers basic but latest understanding of TRIZ and USIT and carries out parallel group practices of solving real problems with USIT. The training was done in 3 days initially, but on requests by industries it has been done in 2 days since 2003 while keeping the contents and the level of results. A recent case of 2-Day USIT Training Seminar is reported in detail in [15].

3.1 Agenda of 2-Day USIT Training with Group Practices

The unique feature of the training is to solve real unsolved problems by group practices. Typically, 3 real problems are brought in by the participants to solve. For each problem a group of 4 to 7 members is formed. It is desirable that the group contains the engineer who owns the problem and other members who are capable to discuss on the subject and to view the problem from different perspectives.

The agenda of 2-day USIT training seminar is shown in Fig. 6 [15]. First, an introductory lecture is given on TRIZ (60 min.) and USIT (60 min.) to guide the engineers who are mostly new to TRIZ/USIT. Then, the group practices of solving real problems are carried out all through the agenda along the standard process of USIT.

The problems are presented to all the participants so as to understand what kind of problems all the groups are to

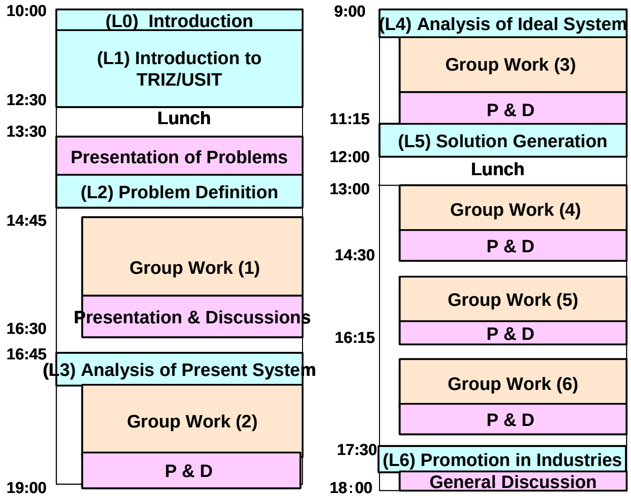

Fig. 6. Agenda of 2-Day USIT Training Seminar

solve. Then the problem definition session starts. At the beginning of the session, a lecture is given to explain about the problem definition process in some more detail with demonstrating several case study examples. Then the groups make real exercise in parallel to define the problem through their discussion. Then the groups report their results in detail by showing the raw records of sketches, comments, etc. on the whiteboard or post-it notes on big sheets of papers. Through the presentations and discussions, all the participants understand all the problems better and how the groups made progress to reveal the problems.

Then the second session is to analyze the present system with USIT, where space characteristics, time characteristics, functional relationships, and attributes relevant to the system mechanism are analyzed (in the order supposed to be suitable for each problem). A short lecture, group work, and presentation & discussion are carried out in the sub-sessions as before.

On the second day morning, images of ideal system is figured out by use of the Particles method in USIT [3], an extended version of Altshuller's Smart Little People's Modelling. With the aid of Particles, i.e. imaginary substance/field which can do and can be anything, desirable actions/behaviours and desirable properties are imagined for the ideal system. Such desirable actions/behaviours are listed up and drawn in a hierarchical diagram. This stage is still in the analysis stage in USIT, but much close to the next stage of idea generation.

Then in the solution-generation stage, a lecture is given to explain the USIT Operators, i.e. a re-organized and unified system of all the TRIZ and USIT methods [4]. In this stage, the group practices are carried out in three sub-sessions: in the first sub-session participants are encouraged to write down all the ideas obtained during the analysis stage and extend them in various directions. Then in the second sub-session, the ideas are grouped and are further classified to build up a hierarchical system of possible solutions. During this process, derivation of different ideas are encouraged by explicit application of USIT Operators, i.e., pluralizing objects, dimensional change in attributes, re-arranging functions, combining solution pairs, and generalizing solutions.

The third sub-session of solution-generation stage is the process of solution construction. The groups are advised to select several solution concepts which are supposed to be most effective, feasible, and novel among the ones obtained so far, and try to enhance them by solving any apparent difficulties in them.

Each group usually derives 30 to 50 solution ideas and 5 to 10 selected solution concepts at the end of the group practices of these 2 days. And all the participants understand how the three groups analyzed the problems and generated solution concepts along the process guided by USIT.

The final session is kept for a lecture and discussion of how to promote TRIZ/USIT in industries.

3.2 Effects of the Training in Industries

The present author has conducted the 3-Day or 2-Day USIT Training Seminars for 33 times so far for these 8 years.

Initial 8 Training Seminars were conducted in 3 days in the period from 1999 to 2002. We typically handled 4 problems in parallel. Three day agenda is nice in the sense that we have an overnight free time after defining the problems and another night after fully analyzing the present system and the ideal system, thus the solution generation on the third day is well prepared by each participant.

The Training Seminar was shortened into 2 days in 2003 on the request by an industry who wanted to try a second in-house training seminar. It was risky at first, but was found possible and successful as the results of accumulation of experiences in the Instructor. The number of problems was reduced to 3 as a standard. The group practices are done intensively as before.

Solving 3 different problems has the effects for the participants to learn necessary or appropriate variations in applying the methodology to different problems. Quite different fields and types of problems are often brought in a training seminar. This variation is also necessary especially in an open training seminar in which people of different interests and different background take part.

So far the training seminars were conducted 21 times under the in-house situation. Promoters of TRIZ/USIT in the industry organize the seminar by finding suitable problems to solve and by arranging the participants. Since the participants usually have good background knowledge of the problems and have reasonably high motivation, the introduction of USIT to them can be straightforward. By the involvement of some members of different sections, the discussions can be stimulated well through the USIT procedure.

It is remarkable that the same training seminars were conducted 12 times under the open multi-company situations. Some TRIZ/USIT promotion organizations organized the training seminar by public announcements. Engineers of different companies join the seminar.

The most delicate issue in this situation is forming the agreement among all the participants on the handling of the results of the seminar and on the non-disclosure of problem-proposing company's secrets. We established a special agreement for this purpose resulting in the larger win-win-win with smaller loss-loss-loss relationships among the problem proposers, other participants, and the instructor [8].

Under such an arrangement, the open Training Seminars have been conducted with highly motivated and frank attitude. Some of the results of such seminars have been published already as case studies [15].

In the training of engineers, small examples and fine case studies are absolutely necessary for their better understanding and higher motivation. People are apt to request examples made in nearby fields; but examples clear and novel in the thinking process are often more instructive. Thus case studies obtained in the open training seminars or obtained by students for everyday life problems such as the one shown in 2.2 are useful.

In these 2-day USIT training seminars the engineers can analyse the problems well and generate good solutions by the group practices with the guidance of USIT and with little assistances by the instructor. You should remember that 3 real problems which the instructor, i.e., the present author, does not know beforehand are solved in parallel by group practices. Hence the instructor can advise how to think in USIT from time to time but can never be able, and is not expected, to solve the problems for himself. The results of the seminar are mostly obtained by the engineers with the guidance of USIT method.

Almost all the participants of the training seminar now understand how they actually applied USIT to the problem solving. But their capability of applying USIT to other problems are often not enough unless they try to study more about TRIZ/USIT for themselves and to keep applying USIT to other real problems. I suppose that engineers or managers in engineering who attended my USIT training seminars 3 times, i.e. having experiences of solving 9 problems, can obtain the capability of guiding other engineers to think in USIT. Probably at least 10 people in Japan currently achieved the capability of leading/instructing creative problem solving with USIT in their own organizations.

4 EDUCATION OF UNDERGRADUATE STUDENTS: LECTURES AND SEMINARS

I have been teaching undergraduate students at Osaka Gakuin University since 1998. Among a number of classes I am/was teaching, experiences of three classes at Faculty of Informatics related to the theme of creative problem-solving thinking are described here [9]. They include:

A lecture course for 2nd (and over) year students on the topic of 'Methodologies of Creative Problem Solving'. In the Fall (i.e. second) semester, 13-15 lectures of 90 minutes are given to 50-60 students in a non-mandatory course.

A seminar class for 3rd year students in a small group (3rd-year students are dispatched to different seminars according to their preferences). The number of students in my seminar class ranges from 1 to 5 depending on the year. In the curriculum, students are recommended to take the above-mentioned lecture class prior to come to my seminar; but sometimes some students join my seminar without taking it. In this seminar class I teach mostly with case studies and in group practices of solving everyday-life problems.

A seminar class for thesis work for the 4th year students who took my seminar class in the 3rd year. In the latter half of the 4th year the students are required to work on individual topics as their theses, i.e. to solve an everyday-life problem creatively by using TRIZ/USIT.

The most important and difficult issue in the education of underground students in the topics of creative problem solving thinking is how to motivate the students toward this topic and give them sound understanding of the topic starting with little background knowledge about technologies and about system thinking. For this purpose we need much longer time for teaching students than for training engineers.

4.1 Lecture Class on Methodologies of Creative Problem-Solving

This lecture course was established by my initiative when our new Faculty of Informatics started in 2000. The course is not compulsory, but about 50-60 students take it every year.

The students at the 2nd year in our Faculty usually have no experiences of working in industries, reading patents, drawing design diagrams, developing real software programs, machining, doing brainstorming, writing research reports, etc. The students also do not have enough knowledge to understand physical or chemical mechanisms of technical systems and their problems. Systems thinking is also new to them. Above all they have never heard about TRIZ or USIT before this lecture, and they never think themselves so smart to invent anything.

Under such a situation, this lecture course needs to be wide enough to stimulate the interests of students, easy to understand without requiring much technological knowledge, and attractive by showing simple yet novel examples.

With these intentions I have made the following 15 lectures in 2006 [9] (See 13 lectures in 2001 in [16]):

(1) An easy introduction

In our era of severe competition, we need creative innovation in industries and in society. So in this Class I am going to explain methodologies for thinking in flexible and creative ways and for solving problems systematically. Then I present slides of several simple case studies, including the Needle & String case described in section 2.2 and the case of a water-saving toilet system.

(2) Three principal approaches of studying and applying science and technology

The first approach starts with observations and tries to derive and verify hypotheses (Induction approach). The second approach starts with principles, i.e. highly verified hypotheses, and tries to apply them to various situations by using scientific reasoning (Reduction approach). These two approaches have been mostly taught in school education, but in the real world we often need the third approach. I.e., we start with problems, try to analyze them for finding solutions, and finally apply the solutions in reality. The present Class focuses on the third approach.

(3) Finding the problem, focusing on it, and collecting information

Finding or noticing the problem is necessary first of all. This can be achieved only with high motivation. Problems which must be solved, whose solution would give much benefits, and whose solution has much needs in society, are good candidates for making efforts for solving. Think over the problem in a wider and higher perspective, find the core of the problem, and concentrate your efforts onto it.

(4) How come up with ideas?

Good ideas often come up suddenly like an enlightenment after a long period of thinking and struggling, and especially at an unexpected relaxed timing. Since there are no guarantees whether and when it comes, we have to do brainstorming, experiments on the basis of trial and error, searching for any hints, etc. This Class will show you some more systematic ways to obtain such ideas earlier and with higher probability.

(5) What are 'Systems'

A system means 'a group of related parts which work together forming a whole'. Such parts may be things, persons, organizations, etc. Systems form hierarchies like supersystem - system - subsystem. Systems may be understood first as black boxes performing some function, by using inputs and resulting outputs.

(6) Finding root causes of the problem

Now let us start analyzing the problem. First, even when we set up a topic of the problem, sometimes it is not clear what is really a problem, or a difficulty/wrong point. Consider harmful/unwanted effects caused by the present problem situation. Next, we need to clarify the causes of the problem. Examine the mechanism in the present problematic system and identify the root causes at the core of the problem.

(7) Analyzing functions and attributes of the technical system

To understand the mechanism of a technical system, the general theory of systems with the concept of 'Objects-Attributes-Functions' is useful. Functional Analysis reveals the functional relationships among objects and Attribute Analysis reveals what properties of objects are relevant to the problem.

(8) Extra: How to construct and write a report.

A basic lecture on how to prepare and write a report/paper for academic/business purposes.

(9) Analyzing space and time characteristics; Making an image of the ideal solution

Clarify the system's characteristics with respect to space and with respect to time (e.g., changes with time, processes, etc.). It is also important to clarify what are the Ideal Situations in contrast to the present problem situations. Make an image of the ideal result, and then consider desirable behaviours and desirable properties of the imaginary ideal system (with the Particles Method in USIT).

(10) Fully utilizing knowledge bases

Now we should go ahead to the methods for generating solution ideas. We should not limit our thinking within our own experiences and expertise knowledge but consult much wider and deeper knowledge of science and technology including those in other disciplines and in other industries. Knowledge bases of principles of science and technologies and patent data bases are useful. TRIZ has created several useful knowledge bases such as Trends of evolution of technical systems, Technical means retrievable from target functions, '40 Inventive principles' in TRIZ, and 'Altshuller's contradiction matrix'. We should learn the basic concepts underlying these knowledge bases.

(11) How to break through the barriers

The critical process in the problem solving is to overcome the barriers (i.e., difficulty or contradiction) and achieve a breakthrough. The most concentrated form of contradiction is named Physical contradictions, where two opposite demands are requested with respect to one aspect of the system. TRIZ claims and has demonstrated that such a form of intrinsic contradictions can certainly be solved by use of the Separation Principles. The case study of a water-saving toilet system is shown as an example.

(12) A system of solution generation methods (USIT Operators)

USIT is a methodology built with the intention of making TRIZ simpler and easier to apply to technical problems. By reorganizing all the different solution generation methods in TRIZ, USIT has built a system of solution generation methods (USIT Operators) having 5 main methods with 32 sub-methods in total. The usage of USIT Operators is demonstrated with examples applied to the Picture hanging kit problem.

(13) Case studies of everyday-life problem solving

For the purpose of reviewing the full course of problem solving explained so far, two case studies of solving everyday-life problems are demonstrated in their full extent. They are: 'How to fix the string shorter than the needle' and 'How to prevent the staple from being crashed'. These studies were the results obtained by the students as the thesis work in my seminar class [13], and were explained at relevant stages of problem solving in the present Class.

(14) Creative problem solving with USIT

As a summary of the present Class, the whole procedure of creative problem solving with USIT is reviewed, in a systematic way by using the materials already explained in the lectures given so far. The overview of USIT is explained first by using the Six-box Scheme and the flowchart. Then the methods at every stage of problem solving are explained with the materials already used in the class. Practical ways of introducing USIT in industries are mentioned.

(15) Creative problem solving with TRIZ, and Conclusion of the Class

TRIZ is underlying most of the lectures in the present Class. Since it is a much larger system of methodology for creative problem solving, I have chosen to summarize it after USIT. Essence of TRIZ philosophy is shown in 50 words in English [2]. TRIZ has built a system of knowledge bases for the use of problem solving in a wide range of technologies and related fields, and has installed them in useful software tools. TRIZ has also developed a large number of methods for analyzing problems and for generating solutions, especially for solving contradictions. Then the history of TRIZ in the former USSR and in western countries is mentioned.

-- Conclusion of the Class: We have learned that we have obtained reliable systematic methodologies for creative problem solving in a wide range of problems. Mastering such a methodology will certainly become a valuable skill for yourself.

For obtaining the credit of the course, students are requested to write a report, not an essay, with 5 or more pages on any topic of their choice and relevant to the present course. They are request to submit the outline in early December, and the final report at the end of January. Some of them write on their own problem-solving case studies, e.g. 'How to play a guitar for exercise without disturbing neighbours in flats', 'How to eat the whole thing of a cup noodle without drinking soup', etc. Topics related to the computer and society are also favorites of students. Even though the effects of this course on students' thinking and their lives can not be evaluated objectively, it is important that a lecture course on 'Methodologies of Creative Problem Thinking' is established and taught on a regular basis.

4.2 Seminar Class for Group Practices

I am teaching a seminar class on the theme of 'Creative Problem Solving Thinking' to a small group of 3rd year students. In such a small group of 1 to 5 members, students' interests, motivation levels, and background knowledge deviate widely. When all the members took my lecture course mentioned above as recommended in the curriculum, the seminar class was smooth in the start and active in operation. (This spring, I am faced with an undesirable situation that 4 of 5 members have not yet taken my lecture class.)

Start of this seminar class in each year needed various trials to motivate the students and to adjust to their interests. In the first two, three years, I tried to use relatively easy textbooks on technological development, on creative thinking, on TRIZ, etc. But such trials always failed because those textbooks are written for engineers and do not match students' knowledge and interests.

It is found that to learn case studies is most effective. They may be technical case studies published by industry people or better be case studies on everyday-life problems solved by students. Such case studies have been accumulated in Japanese recently, mostly in my Web site "TRIZ Home Page in Japan" [7] and in my own laboratory. However, reading those case study papers is not enough for the students to understand. Students should work on the cases, step by step.

Thus, in my Seminar Class we often work on the problems published in the case studies. I lead the process of problem solving step by step along USIT and ask students questions. Doing small experiments, for example fixing the string at the end of sewing in various situations, is also important. Drawing problem situations, known solutions/products, their own ideas, etc. on the whiteboard is also useful; drawing requests them to observe things carefully, to understand the intention in design, to make their own ideas more concretely, to illustrate the things easier for communication, etc.

We also work to make our new case studies on everyday-life problems in group practices. Once we made a series of case studies on 'A system which tells us on the spot that we have dropped or left something behind', 'A system to find a lost child in a big playing park', and 'An on-line system to know the popularity and crowdedness of different corners in an exhibition park', etc. Through these group practices students learn that different members have different ideas on a same topic and hence that it is important to contribute to the group by expressing his own ideas and also to listen to other members' ideas.

4.3 Thesis Seminar Class on Creative Problem Solving Thinking

(1) Activities in the Thesis Seminar Class

During the initial half of the Spring semester of the Thesis Class for 4th year students, the case studies on new problems are usually continued in group practice. Reading various articles and papers on TRIZ/USIT posted in "TRIZ Home Page in Japan" [7] and reading TRIZ textbooks [12] are also encouraged.

The students are requested to find a problem each for their thesis work. When a student brings in a problem as a proposal, we discuss on the problem in the seminar class what target we should set, what kind of approach we should try, etc. In this manner, students fix the problem to solve usually before the summer vacation but sometimes in October (or even in November).

I am requesting the students to work on individual problems to solve in the thesis, in order to make their own responsibility clear and to push them to think seriously. At the same time, since group work is effective and important, we discuss together in the Thesis Seminar Class.

As an official requirement for graduation, the students must submit the extended abstract of the thesis in the end of January. In our Faculty, other details of finalizing the theses are left to the decision by the professors. In my laboratory, the students have to write the thesis of 20-30 pages and have to defend it in the presentation conference held together with another professor's seminar class. The questions/comments by the colleague professor are often very severe, and all my students had to defend their thesis in the second conference in February.

(2) Results of Students' Thesis Works

My students have achieved several nice case studies so far [7, 14, 17]. For example:

- 'Foreseeing the Evolution of Mobile Phones' (Takuo Kasahara, 2004) -- Effective use of the 9-window method.
- 'Improving the performance of a stapler' (Kazuaki Kamiya, 2004) -- Demonstration of SLP modeling.
- 'How to fix a string shorter than the needle' (Tsubasa Shimoda, 2006) -- Simple and nice case study of the whole USIT process.
- 'How to prevent from shoplifting in a book store' (Naoya Hayashi, 2006) -- Finding the core problem in the time analysis.
- 'How to prevent unauthorized persons from entering the auto-locking door of apartment building' (Arata Fujita, 2007) -- applying TRIZ/USIT to a social & technical problem.
- 'Methods of preventing cords and cables from getting entangled/messy' (Tomoyuki Ito, 2007) -- Hierarchical classification of means to achieve a function.

(3) "TRIZ Home Page for Students by Students"

One of the most important achievements by my students is the establishment of a public Web site addressed to students, i.e., "TRIZ Home Page for Students by Students". This site was open in March 2006 [17].

The needs of this kind of Web site is shown clearly from the eyes of students in the following figure (Fig. 7) [14]:

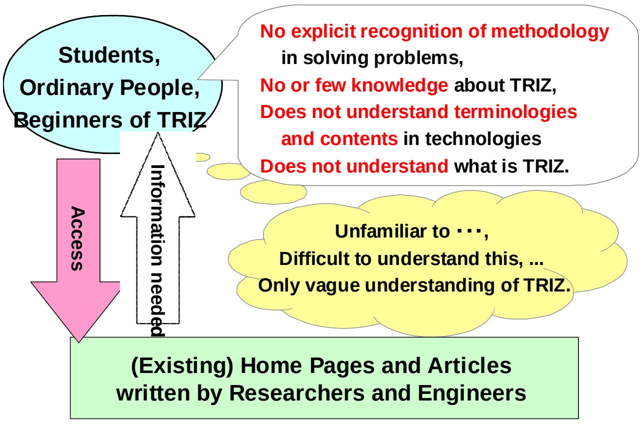

Fig. 7. Needs of TRIZ Home Page for students

The needs are related to the facts that various textbooks on TRIZ and in related areas are not suitable for students because the descriptions are mainly addressed to engineers and not to students (see Section 4.2). The situations are the same for many articles and papers published in my Web site "TRIZ Home Page in Japan" [7], the students say.

Thus the students wanted to establish a Web site on TRIZ/USIT addressed to ordinary students who do not know about TRIZ yet. They decided to post their thesis works and to post some introductory articles on TRIZ/USIT written by themselves. Masayuki Hida, the student leader of this Web project, however, was worried at the end of January 2006 feeling his own Web site unsatisfactory. The parts he wrote on the introduction to TRIZ/USIT were just like records excerpt from previous articles in Nakagawa's Web site or others. They did not have a flavour written by students for students, he thought.

Thus on February 1, 2006 Masayuki Hida talked to other three members what to do about the students' Web site and what do they think about things they learned in the Thesis Class. I happened to enter the seminar room when the talk just started, and I encouraged them to continue their discussion and recorded their talk on the whiteboard in the style of mind mapping. After 30-40 minutes of discussion, Hida and the students found their discussion most valuable to post in the Web as the introduction to new comer students.

The students discussion was posted with the title 'What we think we obtained by studying TRIZ/USIT'. Here are some comments taken from the discussion [14]:

- At first we did not have much interests in it; we started to learn it without knowing what it is.
- By the experiences of practices of solving problems, we have been attracted with TRIZ little by little.
- In my everyday life, when I meet some problem, I now find myself trying to analyze the problem and to figure out solutions.
- Though I was poor at making ideas, I now feel that I myself is able to think of something new.
- I have found that rather than thinking alone, thinking in collaboration with my Seminar group members brings us new findings and new ideas and hence much better solutions.
- I am interested in analyzing problems and finding solutions with explicitly applying the thinking methods which we were usually not aware of.
- Thinking in space and in time: We did much vaguely before, and now learned to do it more logically.
- We have noticed that thorough analyses are essential for problem solving.
- While solving several everyday-life problems in the seminar, I really feel the improvement of my capability of problem solving.
- Apparently ridiculous ideas and images of ideality are the eggs of gold, I realized.
- Even though it is possible to challenge a number of problems in the university, it is often impossible to really make prototypes and examine the solutions due to lack of technologies and practical environment.

5 CONCLUSION

With the growth of my own understanding in TRIZ and USIT, the contents of my lectures to students and those of my training seminars for industry engineers have become richer and yet simpler and more unified. The much stress in TRIZ on knowledge bases has been reduced and different methods of problem solving in TRIZ have been reorganized and standardized in USIT. In place of the large number of parallel models accumulated and used in TRIZ (and in standard science and technologies) in its Four-Box Scheme, we now use a set of standard method for the problem analysis and solution generation in the new Six-Box Scheme of creative problem solving.

These contents have been trained successfully to industry engineers in the 2-Day USIT Training Seminars both under the in-house and the open multi-company situations. Examples of simple case studies are useful in training. The group practices of solving real unsolved problems are valuable in the training seminars.

The essentially same contents on creative problem solving thinking have been taught to university undergraduate students. However, since students do not have enough background in technologies and do not have experiences and motivations, the contents should be introduced to them much slowly by showing many simple, easy-to-understand examples and case studies and by explaining wider basic concepts.

For undergraduate education, the combination of one-semester lecture course of the methodology, one-year seminar class for group practices, and one-year seminar class for thesis work has been found effective and necessary for the student to understand and master the creative thinking for problem solving. Working on published case studies and actually solving unsolved problems in group collaboration are important. For this purpose, everyday-life problems are useful as the theme.

Well-worked-out case studies of everyday life problems are found valuable for both training engineers and educating students. Students seminars and open training seminars can be good sources of such case studies.

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