Abstract

One universal finding for all the TRIZ teaching mechanisms is that learning takes place when the student applies the new concept to his own situation, but that many students never make that step because of fear—the consequences of being wrong outweigh the benefits of learning. Community resources such as museums and amusement parks can become an important part of the teaching/learning method, giving the student a safe environment, with easily understood technologies and business systems, to practice the application of classroom learning and prepare for on-the-job application.

Keywords
Teaching TRIZ, Learning TRIZ, Resources

1 INTRODUCTION

Learning TRIZ is a function, and the student and teacher are a “technical system” that can be analyzed using TRIZ. The learning function can be improved by applying the analysis. Extensive research on TRIZ education [1] has been applied to TRIZ, to develop training mechanisms that are appropriate for the specific concepts, and adaptable to the students’ learning styles. One universal finding, for all the teaching mechanisms, is that learning takes place when the student applies the new concept to his own situation, but that many students never make that step because of fear—the consequences of being wrong outweigh the benefits of learning.

Applying the TRIZ principles of using existing resources and of adding an intermediary, community resources such as museums and amusement parks can become an important part of the learning method, giving the student a safe environment, with easily understood technologies and business systems, to practice the application of classroom learning and prepare for on-the-job application.

2. THEORIES OF TEACHING AND LEARNING APPLIED TO TRIZ

Bloom’s taxonomy and the recent modifications by Anderson and Krathwohl [2] are well-suited to analysis of TRIZ learning and training, since they use the kind of functional language that TRIZ practioners use in the analysis of technical system performance. Table 1 outlines the stages of Bloom’s taxonomy.

Table 1. Outline of the Revised Bloom’s Taxonomy for Learning [2]

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Description of Students’ Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remembering</td>
<td>Retrieving, recognizing, recalling knowledge</td>
</tr>
<tr>
<td>2</td>
<td>Understanding</td>
<td>Constructing meaning, interpretation, inference, comparison, explanation</td>
</tr>
<tr>
<td>3</td>
<td>Applying</td>
<td>Using a procedure, demonstrating execution of a process, implementation</td>
</tr>
<tr>
<td>4</td>
<td>Analyzing</td>
<td>Determining how the parts of a system relate to each other and to the overall system</td>
</tr>
<tr>
<td>5</td>
<td>Evaluating</td>
<td>Making judgments based on criteria and standards</td>
</tr>
<tr>
<td>6</td>
<td>Creating</td>
<td>Putting elements together into a new pattern or structure</td>
</tr>
</tbody>
</table>

The “name” column identifies the function performed by the student who has reached that level of learning competence. In general, introductory TRIZ classes aim for level 3, at which the student can independently...
apply some of the concepts of TRIZ to a new problem and get useful results. Advanced programs typically go in one of two directions:

A. Bring the student to level 3 on more concepts of TRIZ, so that the student is competent to solve many different kinds of problems
B. Bring the student to level 5 on the initial set of concepts, so that the student is capable of learning the other concepts independently, and so that the student can progress to level 6 either independently or with the help of colleagues and teachers.

The focus of earlier research was on the application of Clark’s methods of instructional design to the concepts of TRIZ to find the right method for teaching each one. [3] She identified five kinds of information that is part of most training, each of which requires a different teaching method, because the students have different neurological paths used for learning:

1. Fact
2. Concept
3. Process
4. Procedure
5. Principle (in the sense of the basic philosophy what is being taught, not a TRIZ Inventive Principle or Separation Principle)

This work has been very useful, but it is incomplete, because the focus is on the student and the teacher in the classroom. The most difficult part of TRIZ training continues to be the stage where the student leaves the classroom, and becomes a TRIZ practitioner, rather than a student, in the job environment.

This is not unique to TRIZ. The effectiveness of training in the business world is most frequently assessed using the Kirkpatrick scale [4]. The four levels of competency introduced by D.L. Kirkpatrick in the 1950’s have endured the test of time because the needs of the industrial training system have been quite consistent, regardless of the changes in the students or what they are studying. The four levels are as follows:

1. Classroom acceptance (the student likes the course.)
2. Competency. The student can demonstrate the ability to perform the behaviours or apply the knowledge taught in the course. This can be by exam or by projects, etc.
3. Application. The student uses the knowledge or displays the behaviours on the job, typically assessed within one month of the class
4. Business benefit. The student’s use of the knowledge or performance of the behaviours causes the business to get the benefits anticipated by the course designers.

Although there is extensive literature on the Kirkpatrick scale and its use, there is very little study of levels 3 and 4. Speculation in the industrial education world is that the education specialists can assess levels 1 and 2 in the classroom, but levels 3 and 4 are in the workplace, and the business managers, who are not education specialists, do not conduct those assessments.

There is also speculation that industrial education specialists do not conduct level 3 and 4 assessments because the results depend on a complex interaction of the training itself (teacher, materials, methods, after-class support), the selection of the students for the training, the support of the managers and the assignments of the students after the training. Education specialists do not want to conduct an assessment, find a “bad” result, then be asked to “fix” the problem causing the bad result, when only the classroom activities are within their purview.

There is both overlap and contradiction between Bloom’s taxonomy and the Kirkpatrick scale. Kirkpatrick’s level 2 generally describes levels 1, 2, and 3 of the Bloom taxonomy. The key element of the Kirkpatrick scale, which is not part of the Bloom system, is the transition from the classroom to application in the job setting. Our previous work has been focused on the classroom setting, and on finding ways to teach the various elements of TRIZ to make it easy for students with various learning styles to understand and use TRIZ. [1] This research was necessary but not sufficient for helping students, and their organizations to realize the benefits of Kirkpatrick levels 3 and 4, since that classroom competency must move outside the classroom, into the work environment, for the business to reap the benefits of the training investment.
Understanding the needs of the students and the needs of their businesses stimulated the investigation of ways to increase the success of the transfer of TRIZ learning from the classroom to application both short term and long term in business.

3. HISTORY OF TRIZ TEACHING OUTSIDE THE CLASSROOM

3.1. Early History: Teaching Patterns of Technology Evolution

Boris Zlotin [5] and Lev Shulyak conducted a tour of the Henry Ford Museum in Dearborn, MI USA as part of the education and culture program for TRIZCON1999, the meeting of the Altshuller Institute. The focus of that tour was on recognizing the patterns of evolution in many different technologies at many different points in history. It was very much appreciated by the participants for multiple reasons:

1. Seeing real examples of technological progress as they were originally built, not in cleaned-up drawings or photos, was very helpful in assessing the technologies and the problems being solved, for everything from James Watt’s steam engine to the complete history of the transatlantic communication cables

2. Walking between exhibits gave the participants time to think about what they had seen, and to talk to each other about how each exhibit related to things that they were familiar with.

3. Participants could talk informally with the instructors, and many made their own suggestions about alternate patterns of evolution to consider for specific exhibits.

Zlotin has made these tours a regular part of his courses because of their effectiveness. He based the program on Altshuller’s teaching method and his own experiments prior to emigrating to the US.

Altshuller used arts for inciting creativity and imagination. He had a lecture based on the work of Lithuanian artist Ciurlionis which he used in combination with more conventional teaching.

Zlotin later prepared a TRIZ tour for Hermitage in St. Petersburg showing patterns of evolution illustrated by subjects in paintings and sculptures. He next organized re tours at the Museum of Artillery and Engineering Corps and the Navy museum. He conducted these tours every year for the graduates of St. Petersburg Public TRIZ University. These tours attracted professional museum guides (some retired colonels or even generals in military museums) because they learned things that they had not known about the evolution of military technology.

Zlotin continued to teach this method of teaching to others, most notably at the ETRIA TRIZ Futures meeting in Graz, Austria [6], with a tour of the classical and modern (some might say “radical”) architecture of Graz.

Figure 1. A. Photo of a model of Graz museum, taken during the ETRA tour at the TRIZ Futures meeting in Graz, Austria, 2006, showing the pattern of evolution of multiple degrees of freedom

3.2 Middle History: Teaching Basic TRIZ Concepts outside the Classroom.

The positive experience with the museum tours used to teach patterns of innovation stimulated the authors to experiment with other tours for other purposes. We have previously reported on the experiment with the 40 principles at Disney World [6]. This method has now evolved as follows:
Contradictions

The students are given a worksheet (see table 2) on which to identify problems and solutions. If the problem is a contradiction, they decide if it is a technical ("tradeoff") or physical ("inherent") contradiction. They then consider whether the contradiction was removed by use of one or more of the 40 principles, or one or more of the separation principles. More advanced students are asked to consider if the contradiction is based on certain assumptions about the solution, and if they could formulate their own solution by challenging the assumptions. Table 3 shows the form used for the example shown in Figure 2, from the San Jose CA Museum of Technology exhibit on applications of technology to solving global education and resource problems.

Table 2. Student questionnaire for studying contradictions

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
<th>Contradiction?</th>
<th>Solution type</th>
<th>Assumptions?</th>
<th>Alternate Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Example of Table 2 completed for the case study shown in Figure 2.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
<th>Contradiction?</th>
<th>Solution type</th>
<th>Assumptions?</th>
<th>Alternate Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls don’t go to school</td>
<td>Make rolling water barrels from discarded</td>
<td>Yes, technical</td>
<td>Water must</td>
<td>Use pumps</td>
<td></td>
</tr>
<tr>
<td>because they spend all their</td>
<td>shipping barrels, carry 5x the water per</td>
<td></td>
<td>be carried,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>time carrying water</td>
<td>trip</td>
<td></td>
<td>the less time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>for school.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Girls transporting water using the Hipporoller, shown in an exhibit of global innovation to improve people’s daily lives at the San Jose Technology Museum, San Jose, CA, 2009. [7]

Similar worksheets are used for analysis of situations that show solutions of problems using resources and solutions of problems by increasing ideality.

3.3. Recent Developments

Leaving the classroom environment for museums, parks, amusement centers, etc. has great appeal for the students as well as the instructors. Since an experienced instructor can convert any technical, social, or business change into a TRIZ class example, it is tempting to let the museum staff do the work of constantly developing new cases, collecting photos, artifacts, and documents, and constructing exhibits that will give a continuing stream of variety to the TRIZ students.

But the instructor must ask if the additional time required for instruction outside the classroom is producing better results for the students and for their organizations. Even though it is seldom possible for an outside consultant to conduct a full Kirkpatrick-style evaluation, it is nevertheless possible to interview
class participants and their managers and make informal assessments, as was done for several years with these methods.

The most surprising result of the interviews was the remark from many students that going outside their own company environment removed the fear that they had of being too innovative, or being perceived as being too innovative, which they felt was interpreted as being too risk-prone, inside the company. This remark was repeated in many circumstances, in companies that are noted for innovation and in companies where TRIZ training was introduced to overcome a limited innovation environment.

Only a few students remarked at length on the entertainment value or the cultural value of the trips outside the classroom. For most it was seen as a way to give them case studies outside their own business environments, which reduced the fear noted above. Many also noted that the advantage of the museum trips in particular was that the social and technical issues of the exhibits were thoroughly explained, so the students did not have to spend time researching case studies. After practicing in cultural or entertainment venues, the students reported no difficulty transferring the learning into their business environments.

These results have suggested new experiments in providing students with opportunities to learn TRIZ in safe environments, where their fear of being judged by others in their company can be minimized. Depending on the time available for the activity, the following recommendations can be made:

- **Fifteen minutes:** Study something in the training environment, not connected to the participants’ daily work. Popular subjects are environmental controls for buildings, power conservation in buildings, and operation of the food service area.
- **Two hours:** Use retail stores in the neighborhood of the training location. The students can study the products in the stores or the operation of the stores themselves (including restaurants, if the instructor can get the cooperation of the management and kitchen staff.)
- **Four hours:** Trip to a local museum or entertainment park. History, natural history, and technology museums are all effective. Zoos and aquaria are effective if they offer a tour behind the public areas, where students can study the problem solving methods used by the developers. These tours are frequently not publicized but available on request as educational opportunities.

### 4. Summary

There is a long history of experiments with teaching TRIZ outside the classroom for many reasons. The goal of teaching TRIZ in a way that facilitates transfer outside the classroom, to the students’ work environment, and facilitates the students’ progress to high levels of mastery has benefited from these experiments, for both the expected reasons of matching the types of learning to the different types of material being taught, and the unexpected reason of overcoming students’ fear of being judged.

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