Using an "ideality-first" methodology to evolve the requirements of a software product

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Abstract

Using the traditional Innovative Workbench methodology, one would first construct a model of the system under study to identify areas for improvement and then employ one or more TRIZ-based principles to overcome the challenges and improve the system. Since we sought to create a new product intended to bring TRIZ-based learning materials to elementary school students we could not create this initial model. Instead we improvised and worked backward toward the solution by first developing an ideal model and then comparing that to the Innovative Workbench tool itself. In effect, this showed us how to transform the tool into the age-appropriate product we were seeking.

Introduction

Children are natural innovators. Not having yet learned constraints about the world, children naturally explore alternatives and experiment with new ideas with an ease that we lose as we get older. As we age and achieve higher levels of education, our innovative and creative abilities become more sophisticated but also more inhibited. In fact, a major goal of TRIZ-based methodologies and tools is to help people overcome this psychological inertia we build and improve the ability to "think outside of the box." We see this phenomenon in microcosm in the undergraduate courses we teach. Routinely, freshmen, when presented with a rather open-ended toy problem requiring innovative thinking, will immediately set about offering several different potential solutions—many not at all practical—but all very creative. However, seniors, when presented with the same problem, are frustrated with the open-ended nature of the problem and typically ask a series of questions attempting to narrow the problem. The solutions the seniors eventually synthesize tend to be more practical, but less creative. Are we educating innovative and creative thinking out of our graduates?

One troubling observation is that neither group of students seem prepared to "think outside of the box" nor do they display well-formed innovative skills. We need to teach students how to think innovatively and creatively when they are young (in the elementary school grades) and empower them with a set of tools and techniques they can carry with them into later life. The feeling is if we can teach children to harness their innate creativity in a structured and repeatable way, it will become a skill they can carry through life. Maybe one day, we will see freshmen and seniors both be bored with our toy problem and also able to dispatch it with innovative ease.

TRIZ-based analysis and solution formation is the perfect way to teach children how to innovate in a structured and repeatable fashion. With this premise, we (an assistant professor and two undergraduate student assistants) embarked on a semester-long project to design age-appropriate courseware and instructional material for 3rd-6th grade students featuring TRIZ-based training. We call our product *Make-A-Betta* as a play on words for "make a better…" with a slight southern U.S. accent (after all, we are from the South). We envision teachers tasking their students to "make-a-betta chair" or "make-a-betta desk."

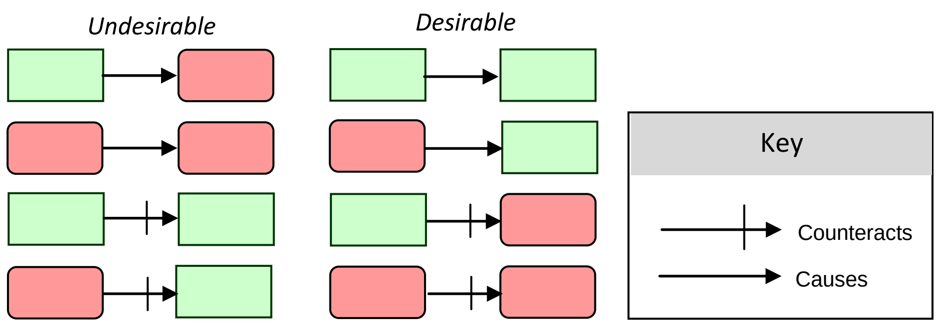
Our challenge was twofold. On one hand, we had to figure out what features such a product should have to be successful in the target demographic. On the other hand, we had to figure out how to translate existing TRIZ-based methods and knowledge into elementary school course materials. Early on we naturally hit upon the idea of using our TRIZ-based tool, Ideation International's Innovation Workbench (IWB) to help us. We immediately ran into a problem. The IWB is traditionally used to incrementally improve an existing system by identifying one or more problem areas in the system under study and helping practitioners devise improvements. However, in this project, we were not seeking to improve something already in existence, so we had to improvise the methodology. Using the diagramming tool called the Problem Formulator, we first developed a model of the "ideal" product by identifying essential features of highly successful products like iPod and WebKinz. Given a picture of what the "ideal" product should look like, we then compared the IWB itself against the ideal model. This effort gave us an idea of how we could morph features of the IWB into the age-appropriate product we were seeking and also which features we needed to add to insure mass-market success. The "ideality first" methodology we improvised could work with any endeavor. Instead of starting with a flawed system and incrementally improving it, we essentially started a perfect system and worked backwards until we arrived at something we could build.

Problem Formulation

The Problem Formulator is a graphical modeling tool in the IWB permitting users to construct a type of causal diagram of the system under study. Every aspect of the system is classified as either *harmful* (undesirable) or *useful* (desirable) and represented as nodes in the diagram by:

Edges in the diagram reflect the relationship between one aspect and another. An aspect can either re-enforce or inhibit another aspect of the system. For example, a useful aspect that re-enforces another useful aspect is a desirable situation whereas a useful aspect that causes harm or inhibits another useful aspect is undesirable. Figure 1 shows possible combinations.

Figure 1 – Aspects of a system can either cause (re-enforce or enable) or counteract (inhibit or prevent) other aspects. Causing harm or inhibiting the useful is undesirable whereas causing the useful or inhibiting the harmful is desirable.

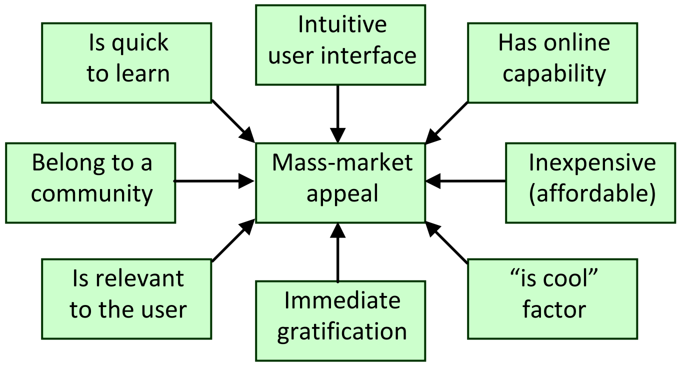


Situations involving undesirable combinations are called *contradictions*. Of course, the goal is to create systems with no contradictions. Such systems would be ideal systems devoid of any non-useful aspects. Contradictions are departures from the ideal and represent opportunities for one or more improvements to be made. An improvement to a system resolving, or mitigating, one or more contradictions is a positive incremental evolution of that system toward the ideal. In the case of our Make-A-Betta product design, we were not seeking to incrementally evolve an existing system so we could not draw the initial model. Instead, we imagined that we had already created the ideal product and used the ideal model as a starting point.

The Ideal Model

Our vision for the Make-A-Betta product was one that appeals to millions of school-age students so we decided to first draw a model of an ideal mass-market product. To identify the important features of such a product, we considered several current wildly successful products such as: iPod, iPhone, cell phones, MySpace, WebKinz, and a few others. In each instance, we asked ourselves what the important features were that made these products popular. Incorporating them into a Problem Formulator diagram yielded the model shown in Figure 2.

Figure 2 – The "ideal" model of a product with mass-market appeal. This model was arrived at by looking at the success factors of a number of existing highly successful products used by students.



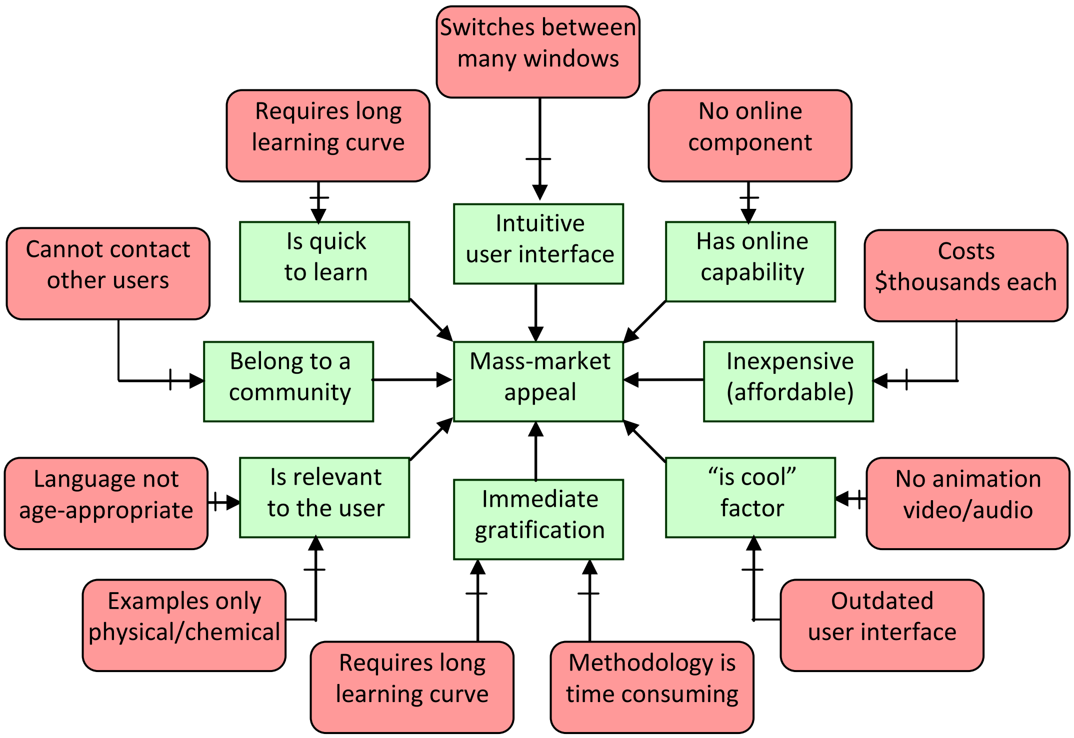
The ideal model is what our product would look like if it were perfect. This is not to say that we captured every feature of a mass-market success and this does not mean that every mass-market success must have these features. However, what we did capture was eight aspects that re-enforce the ultimate goal of being a mass-market success. We can feel confident of these aspects since they have proven to be instrumental in some other products' success.

At this point we needed a way to generate contradictions—so we could have something to solve and generate specific ideas for our product. We chose to analyze the IWB itself against the ideal model. We could have chosen any product for comparison but we felt that IWB was a good choice since it contained the subject matter we wanted to incorporate into the final product.

The Contradiction Model

Our methodology was to consider each of the eight useful aspects in Figure 2 and ask ourselves what about IWB inhibited (counteracted) that useful aspect. The result of this effort is shown in Figure 3.

Figure 3 – The "contradiction" model reveals shortcomings of the IWB when compared to an ideal mass-market success. Each contradiction represents an area where improvements can be made.



The next task was to examine each of the contradictions in the model and generate a list of resolution ideas. For some contradictions, such as *No online component*, the resolution was obvious—to incorporate an online component. For other contradictions, we consulted the IWB knowledge base consisting of over 400 innovative principles, called *operators*, and also used the standard 40 principles from classical TRIZ. Each operator or principle represents a generic bit of innovative knowledge distilled from decades of study of patents and technological advancement. The goal of using the operators is to stimulate the synthesis of improvements to the system. The IWB tool automatically suggests operators for the contradictions. Using the IWB suggestions and the 40 principles, we first individually undertook the task of generating new ideas for the Make-A-Betta product and then met for group discussion. Some of the ideas came about as a direct result of thinking about one or more of the operators. However, some ideas came to us "out of the blue" and did not appear to be associated with the operator currently under consideration. However, we were later able to find an operator or principle that fit these new ideas. Brevity prevents an exhaustive listing of the operators and new ideas. However, the following is a representative sample:

1. Include Completed Projects

Operators Employed:

improve the speed of an action, use a model or a copy, preliminary action (partial or complete)

Idea Generated

Instead of requiring the student to synthesize everything from scratch, include projects either completely worked or partially worked. When first learning, to get quick gratification and to focus learning, students can view all steps of a completed project to see how it is accomplished. In this way, students will see results within minutes.

2. Have a Preferred Path Through "Operator Space"

Operators Employed:

make a road (precondition a path you want followed)

Idea Generated

One can easily become overwhelmed and feel lost with the expanse of the ITRIZ operators and knowledge base. The idea is to engineer known pathways through the process but hide these from the user until the user needs "some help to get their bearings." This way, we can be sure students do not "wander into the woods" and also do not become frustrated and terminate their session.

3. Directed Feedback

Operators Employed

feedback

Idea Generated

Given that we will have hidden preferred paths ("roads") through the material (see above), at each step, the software can detect departures from the preferred path and give users feedback in the form of suggestions to encourage them to select the proper choice (rather than simply telling them what the right choice is).

4. Use Age-Appropriate Animated Graphics

Operators Employed

vary optical characteristics, dynamicity (make things more dynamic), specialization

Idea Generated

The target demographic is accustomed to seeing Web sites, television programs, and movies making extensive use of animated graphics. Anything less for Make-A-Betta would cast the product in an inferior light. This also benefits the visual learner.

Make-A-Betta

The end result of this effort was the high-level design of a software product and associated course materials for use in the 3rd-6th grades. The goal of Make-A-Betta is to introduce elementary school students to TRIZ-based thinking and analysis early in their lives in hopes that it will stay with them and be used throughout their lives. With some exceptions, most of the existing TRIZ education material is intended for an adult audience. For example, the IWB knowledge base is replete with physical, chemical, and mechanical case studies, but students in 3^{rd}-6^{th} grades have not yet had enough education to prepare them to understand this material. Also, the ITRIZ operators themselves address scientific and engineering concepts these students are not prepared to work with until high school or college. For these reasons, we decided to embody the effort into a concept that children identify with. All students of that age understand "making something better." Therefore, Make-A-Betta is centered on the idea of taking familiar object and asking students to come up with ideas about how to make it better. We envision Make-A-Betta to comprise a piece of software and associated lesson materials.

Objects and Problem Areas

We envision the software to employ a graphics-intensive Web-style user interface akin to the WebKinz, Nickelodean, and Cartoon Network Web sites. The initial screen will invite the student to "make something better" and offer a scrolling display of images of familiar objects like: desk, chair, bed, bicycle, shoes, car, house, etc. Clicking an image of an object, begins a multi-step process that is either completely scripted (full tutorial mode) or scripted only to a point (the teacher can select the degree of freedom the student has) eventually leading to the identification of one or more improvements to the selected object. For each object, the software will present a menu of problems (areas for improvement) associated with that object. For older students, the software will ask the student to identify problem areas themselves. We felt that asking 3rd-6th grade students to draw the "contradiction model" for their selected object was too advanced. So, this analysis will have already been done by the developers yielding the list of problem areas to choose from. However, we are not so smug as to think that we have identified all problems with all objects. The more advanced students will be able to identify their own problem areas and share with students around the world as explained later in the section discussing online connectivity.

Angles of Attack

The student will be invited to explore the problem areas and asked to select one. Once selected, a list of "angles of attack" for the chosen problem is displayed. Throughout, the language used will be adjusted for age. For example, instead of displaying messages such as "increase effectiveness of the system" (as currently seen in the IWB) the software will display clearer and specific messages such as "make the desk easier to move." Each angle of attack will have been analyzed by the developers using the IWB, so the software will offer to the student specific changes to choose from. Since this is a product intended to teach thinking skills, the teacher will be able to change the "fidelity" of the offerings to the students. At first, only correct angles of attack will be offered. As the student progresses, the software will add incorrect angles of attack to encourage the student to make judgments on their own. When a student selects an incorrect angle of attack, the software will explain why that choice was not the best option providing both positive and negative feedback to stimulate learning.

Improvements

Once an angle of attack is selected, the student will be presented with a list of primitive operators they can use to think of an improvement to the object. Again, the language will be age-adjusted. At the outset, all operators will be appropriate, but as the student progresses, inappropriate operators will be added to the list of choices and the student prompted to make a proper choice. Feedback as to why an inappropriate choice is undesirable stimulates learning. For the most advanced students, an option will exist allowing the student to browse the whole of operator space and make the choices on their own. The goal of this part of the exercise is for the student to make the leap in applying the generic concept, represented by the operator, to conceive of a specific improvement to the object. Some improvements, pre-engineered by the developers, will be available as hints if the student requests help, but the personal creativity of the student is encouraged here.

Online Connectivity

Make-A-Betta will also serve as the student's interface to an online community of students around the world also using Make-A-Betta. We see this as a critical component of the product but not just because the target age group expects products to be "connected and online." The goal of Make-A-Betta is to prime young minds with something they take with them through life. Through the online community, students will see large numbers of others like them using these skills and therefore promote adoption.

Through the online community, students will be able to see the creative efforts of other students. When stumped at any point in the process, or just when interest strikes, a student will be able to click to see "what others have done here." It is expected, and will be encouraged, that virtual collaborative groups of students will evolve organically out of the interaction between co-innovators.

Conclusion

Our goal in this effort was to conceive of a way to introduce TRIZ-based creative and innovative thinking to elementary school students (3rd-6th grades). Being familiar with the IWB, we sought a way to translate the knowledge and skills encapsulated in that application into an age-appropriate delivery. We naturally decided to use the IWB itself to help us but because we were embarking on a different kind of project than was intended for the IWB, we improvised part of the methodology. Our positive result indicates other practitioners could benefit from our experience. Because we were not seeking to improve an existing system, we diagrammed an ideal model first drawing from ad-hoc analysis of existing mass-market successes in the target demographic. We then compared the IWB itself against this ideal model thereby generating several deficiencies we needed to overcome. If we had drawn the traditional system diagram first as the IWB methodology demands, we would have missed most of the critical features that promise to make our product a mass-market success.

In retrospect, the "ideality first" method we improvised should not have been that much of a surprise. One of the system analysis tools in the IWB methodology is *idealization* which includes six ways to increase ideality of the system. Also, a basic principle in TRIZ is the *Principle of Ideality* indicating one can approach perfect ideality by either increasing the number of useful aspects of a system so as to dwarf the number of harmful aspects or to eliminate the harmful aspects altogether. In drawing the "ideal model" first, we essentially eliminated all negative aspects.

However, equally important was our choice of the central node in the ideal model (Figure 3). Given our goal of wishing to bring TRIZ-based training to young minds, we could have easily chosen a central goal of “Teach TRIZ to youngsters.” It would have been impossible to draw an ideal model built around that goal, since it simply begs the question of our effort itself. Instead we asked ourselves what would make youngsters adopt whatever we created and make it so popular as to compel young minds. We answered that question with “if we made it cool like the iPod” and that led us to “mass market appeal” as the central goal.

In conclusion we would like to stress that there is more than one way around and through a methodology and being creative enough to improvise and innovative enough to ask and answer tangential questions sometimes wins the day. Our tools are just that, tools. Using them is sometimes an art.

Dr. Fulbright holds a PhD in computer engineering from the University of South Carolina and has over 25 years of experience in computer engineering, software engineering, and information technology. As the inaugural chair of the Department of Informatics at the University of South Carolina Upstate, Dr. Fulbright is leading the development of a novel multi-disciplinary program in applied information technology and information management. Current research interest includes: computer-aided innovation, emergent systems, and complex adaptive systems. Previous research experience includes: autonomous underwater vehicles at Penn State University's Applied Research Laboratory, autonomous mobile robotics at the Department of Energy's Savannah River Site, and distributed artificial intelligence with the University of South Carolina. Non-academic experience includes collaborative solutions design and development for Fortune 100 companies, first-in-class Internet-based e-commerce solutions, and automation engineering