# Operating a Successful PowerTech Creativity Contest

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## Abstract

To help cultivate future talent for creating technology, the PowerTech Youth Creativity Contest was first held in 2000 by the Taiwan Creativity Development Association (TCDA) and the National Taiwan Normal University (NTNU). It has since been organized regularly on a yearly basis, with the number of contending teams growing from 78 in the first year to 414 in 2006 (3-4 members each team). The categories have been extended from the elementary school level to include junior high school categories. The activity design adopts the project-based learning approach and aims to develop important technological creation abilities for students, particularly with respect to knowledge application, psychomotor skills, and creative thinking in which the planning ability, imagination, analytical skill, and implementation ability will be developed, and some affective domains such as persistence, high regard for efficiency, quality improvement ability, and teamwork spirit will be cultivated through project competition and realization.

The purpose of this article is to describe the operation principles behind the PowerTech contest from four different dimensions: (1) contest design and its rationale, (2) contest promotion which includes the application of information technology (IT), and the social resource identification and application. It is hoped that the discussion of this article will be valuable as a referential basis to organizers of similar activities.

## Introduction

Education reform is a necessary means to the enhancement of national competitiveness, including intra-institutional or extra-institutional educational reform measures aimed at equipping learners with creative abilities or problem – discovering and solving skills. The ability to create technology, in particular, helps lay the foundation for national competitiveness. This is why the cultivation of technological - creating abilities in the younger generations has always been among the top priorities of domestic educational reform measures. In light of this, technology educators too should strive to broaden and deepen their effort to create technological ability in young students.

According to the investment theory of creativity by Sternberg (1995), creativity requires a confluence of six distinctive resources: intellectual abilities, knowledge, thinking styles, personality, motivation, and environmental context. In other words, in order to create effectively, individual creators must possess sufficient domain knowledge and realize their full intellectual potential. To help technology take root, educators need to devise a group activity and a mechanism to involve students and encourage them to explore technological inventions. This paper therefore focuses its discussion on the operations of the PowerTech Youth Creativity Contest (henceforth PowerTech Contest) from the group activity-mechanism perspective.

## The Rationale of PowerTech Contest

Sternberg (1985) developed a triarchic theory of intelligence, highlighting the individual differences in intelligence and dividing human intelligence into analytical, creative, and practical intelligences. These are described as follows: (1) analytical intelligence includes the ability to analyze, compare and contrast, evaluate, explain, judge, and criticize, (2) creative intelligence includes the ability to create, design, invent, imagine, and suppose, and (3) practical intelligence includes the ability to use, apply, implement, employ, and contextualize.

In other words, technological creation should be a comprehensive embodiment of a pool of integrated abilities, including knowledge application, practical intelligence, thinking ability, and action taking (Magee, 2005). Taiwanese students in general perform very well in knowledge memorization and reasoning, but they are rather weak in knowledge application and innovation. Regarding practical intelligence, the majority of the students in Taiwan are lacking in hands-on experiences. Many school assignments that require hands-on practice are often done by parents. In terms of thinking ability, the current constructivist teaching approaches in Taiwan have led to a general lack of plurality and flexibility among students, particularly with respect to their problem-discovering and problem-solving abilities. The situation is worse with elementary school pupils because the younger the age, the more easily bored the students become. This shows that domestic students in general lack the abilities to implement and complete a task.

Given this background, many nationwide contests to create technologies have based their contest design on the successful development of such abilities as knowledge application, pluralistic and flexible thinking, practical intelligence, and a careful attitude in students. According to the spirit of the Nine-Year Integrated Curriculum for Mandatory Education in Taiwan, a domestic technological creation contest should strive to cultivate the following 10 abilities for students:

1. Self-understanding and potential development.
2. Appreciation, performance, and innovation.
3. Career planning and life-long learning.
4. Expression, communication, and sharing.
5. Respect, caring, and teamwork.
6. Cultural learning and international understanding.
7. Planning, organization, and implementation.
8. Technology and information application.
9. Active exploration and research.
10. Independent thinking and problem solving.

Furthermore, technological creation contests for youths have the following personal, societal, and economic benefits:

***1. Individually***

a. Pre-production design drawing improves planning ability.

b. Flexible thinking and knowledge synthesis enhances imagination.

c. Project production encourages independent thinking and promotes originality.

d. Comparison of their own and rivals' work helps them to learn analytical skills.

e. Utilization of equipment and hand tools for material processing, production, and formative design improves practical skills.

f. Competition stimulates persistence and cultivates sportsmanship.

g. Team cooperation embodies the concept of symbiosis and makes students a better team player.

***2. Socially***

a. The organization of a nationwide contest for technological creation helps involve people at all levels of the society and boosts their interest in technological creation.

b. The organization of a nationwide technological creation contest increases opportunities for inter-school exchange.

c. The activity itself helps the concept of *technological creation* to take root into the daily lives of the citizens.

***3. Economically***

a. The cultivation of product R&D capabilities helps increase the added-value of technological products.

b. The cultivation of manufacturing R&D capabilities helps boost production efficiency and quality.

## Theme Selection and Its Meaning

From the corporate management point-of-view, the PowerTech Contest itself can be seen as the product, and the participating students are its customers. In order to capture precisely what the market demands are we need to develop and put in place a system of effective management. Cooper (1993) pointed out in his review of three high-tech product cases following the common characteristics of successful technological inventions: (1) close collaboration between the inventor and the customer, (2) well-defined market demands, and (3) the existence of a technical champion. Based on the rationale discussed in the previous section and the past experience of TCDA and NTNU organizing the youth creativity camp activity, the PowerTech organizers selected "The Queen of Ants" and "King of Beasts" as the theme for elementary school students to compete and "The Totoro of Buses" and "The Giant of Bugs" for junior high school student to compete, with an aim to develop the participants' ability to construct and improve their technological knowledge. The contest requires rival teams to apply relevant theories of physics for the internal structure of their invention, including the electrical motor and the gear set in the power system, and the linkage mechanism in the transmission system. Since no specifications and dimension requirements are given for the final product, teams are allowed to fully stretch their creativity and are required to search for the needed knowledge and to put their theories into practice. In addition, students also need to learn to utilize unprocessed materials provided by the contest organizers and apply their creative thinking skills to produce a project. Below is a brief summary of the characteristics of the end product, and the categories and method of the competition.

***Contest Theme Selection***

The elementary school competition has two themes. The first theme "The Queen of Ants" requires a final structure that contains a body comprised of three separate parts linked with a linkage device and a cross-shaped foot stand. The final product is expected to perform the mechanical functions of spinning and crossing a hurdle. The second theme "The King of the Beasts" requires a final structure that has the ability to walk with four legs by using crank and linkage devices. An animal appearance is also an important part of the competition, and the competing teams are free to add any aesthetic element or any defensive/offensive function to their creation.

In junior high school competition, the first theme is "The Totoro of Buses," a four-wheel-drive vehicle with an arch-shaped roof that can maintain a continuous and smooth movement of rolling over when it hits against a vertical wall through its wheel-body coordination and center-of-gravity design. "The Giant of Bugs" requires the use of a linkage structure together with the crank movement and the front-end chassis-to-ground friction design to enable the Bug to crawl forward with alternating stretching and recoiling movements like a caterpillar. The competition is divided into different categories according to the level of difficulty in project production and mechanical requirements, and it is conducted in two stages (preliminary and final).

**Table 1. Four Projects of Technological Creativity Contest**

| Item | Description |
|---|---|
| The Queen of Ants  | The Queen of Ants is a robot with a structure with three interconnected body parts and a crossed-leg design for hurdle crossing. Pupils can learn about the various fundamental technological concepts through the design of a power system, including the gear drive system (the principle of leverage), DC electricity application features (difference between parallel and serial circuits) and component linking methods, all of which are useful for creation of technological products of different mechanical structures and functionalities. |
| The King of Beasts  | The King of Beasts is a four-legged, animal-looking walking robot for use in a wrestling contest. In addition to the relevant principles of physics mentioned above, pupils can also learn about the basics and the design of a linkage structure, and about how to transform the rotary movement of a motor into linear movement, and how to increase friction (by increasing product weight or changing the material texture, etc.) in the contest. |
| The Totoro of Buses  | The Totoro of Buses is a four-wheel-drive motor vehicle with an arch-shaped roofline design to capacitate continuous rolling movement. Through motor-driven vehicle design and production, pupils can learn about gravity (vehicle body's center of gravity) of vehicle body, centrifugal force (generated during rolling), streamline design, etc. |
| The Giant of Bugs  | The Giant of Bugs is a robot emulating the stretching and contracting movement of a real worm for use in a straight-line speed race and a tug-of-war contest. In addition to providing pupils an opportunity to synthesize various concepts of physics and to develop a basic understanding of biology, the product requires the use of environment-friendly materials and processing methods for appearance design. This helps incorporate the concept of biological chain into product design, and this challenge demands a good balance between the mechanical and functional structure of the product and its appearance design. |

*Content Method Analysis*

The PowerTech Contest requires the creative project to be produced and completed on site within the one-day competition. During the production process, all teams work on their projects in an isolated area to protect them against external disturbances and unwanted interferences, including instructions (oral or otherwise) from teacher advisors and parents, who are only allowed to observe the contest from outside the isolation line. This particular arrangement has been used to ensure that the entire competition process and setting are fair, just, and open.

The PowerTech Contest contains three subcategories: power contest (e.g., speed racing and push), form design contest, and innovation process records contest. In power contest, the contesting teams are required to make designs for each required contest item according to the mechanical features under the given theme. At the same time they must take into consideration the respective constraints of each required item, and then seek to optimize the mechanical design. Table 1 summarizes the different contest items for respective themes.

In the innovation process records contest, an expert review meeting was convened one week before the final competition to evaluate the innovation process records of the rival teams, which should include their problem-discovering and problem-solving methods, idea-searching and idea-generation methods, and technological innovation processes that were recorded during their meetings with their teacher advisor. The form design contest was held on the day of competition, and the evaluation is based on the contesting teams' overall structure design, color applications, environment-friendly material employment, and processing skills. The final score is determined by the total score of all the subcontests. In other words, the contesting teams are required to put in a carefully measured amount of effort into the respective preliminary contests in order to win the game. Through participating in the entire process from planning and design to pre-contest practice and the final competition, students should be able to develop a basic design concept that emphasizes not only the mechanical function but also the formative design, instead of overemphasizing one aspect at the expense of the other.

## Operating a Successful PowerTech Contest

The goal of the contest is to help students to learn to utilize limited resources to achieve project objectives through planning, implementation, and evaluation. Therefore, the operation of the PowerTech Contest should cover all aspects of resources including people, processes, materials, and finances. As a regular activity of a nonprofit organization, a PowerTech Contest indeed faces serious obstacles in all aspects in its pursuit for sustainability. Hence, an effective management mechanism is required in order to help the contest overcome the various challenges it may face in the course of development.

As already mentioned in the previews section on PowerTech Contest rationale, in order to create a technological project, students must have abundant knowledge and possess various skills and capabilities (including knowledge application, plurality and flexibility in thinking, and implementation and persistence). The Ministry of Education has also pointed out that technology should be an integral part of the learning of Natural Science and Life Technology in its Nine-Year Integrated Curriculum for Mandatory Education. Currently, however, students' understanding and skills for technological creation remain largely insufficient for a successful implementation of the new curriculum. Therefore, in preparing for the contest, the organizers foresaw several problems. First, who should be the target audience of the contest? Because students largely lack technological creation capabilities, the end "product" may not be one that could be sold on the market, and the goal of helping to cultivate students' technological creation abilities may not be fully realized. The second challenge was about how to get the word out to the target audience. What could be done to improve the visibility of the activity among possible contestants? This second question would entail marketing.

The organizers mistakenly decided to address the second question first during the first-year of the contest due to a lack of experience. The organizers adopted a media propagation strategy, but much of the effort was to no avail. That experience taught the organizers to deal with the first challenge first in order to process a successful event. In addition, for the contest to continue yearly, the organizers also need to address the issue of sustainability. And this third problem has to do with the sustaining of participants' motivation and interest. Below is a brief discussion of how these three difficulties can be resolved.

***The problem of "Who is Capable?"***

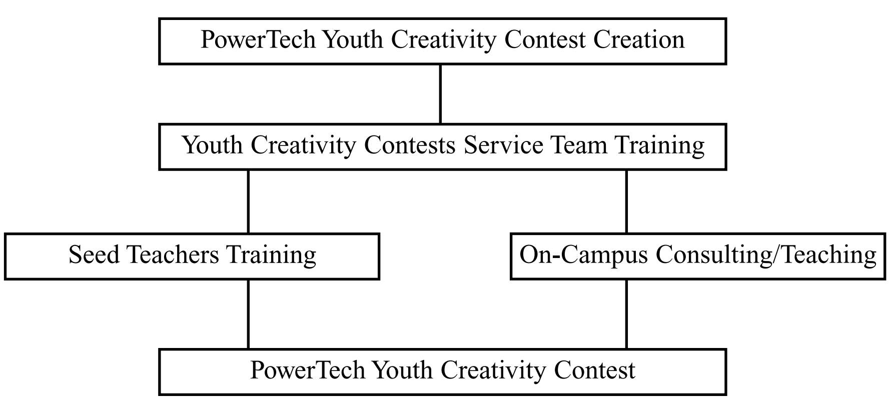
Since most of the students had no previous experience making technological creations in school, they probably had little self-confidence for such a contest. It is therefore important to provide a learning opportunity for those who were willing to give it a try. Also, considering the fact that the contest is at "national level," such a learning opportunity has to be provided nationwide, not limited to certain cities or counties. According to "The Tipping Point: How Little Things Can Make a Big Difference" (Gladwell, 2000), a contest must have relevant connectors in order to become popularized. In other words, teacher's interest has to be cultivated first, instead of students, and they had to be provided with technological creation experiences. The organizers therefore recruited students from college-level teacher-education programs to form the Youth Technological Creation Service Teams and to provide necessary training to them. The purpose of setting up these teams is twofold: (1) to provide an educational internship opportunity for these college students, and (2) to reduce the budget requirement for organizing teacher-training programs as part of the PowerTech Contest promotional campaign.

During the second-year PowerTech training, the service teams used the National Museum of Natural Science and the National Science and Technology Museum as their bases to train seed teachers by stages and to utilize various collaborative learning mechanisms through knowledge collection, diffusion, transmission, and innovation in order to help the trainees to help their students. In addition, to increase participation rate, the service teams toured elementary and junior high school campuses to provide guidance and to help increase the ability and confidence of prospective participants. The flowchart of the PowerTech Contest is shown in Figure 1.

***The problem of "Who should promote to?"***

Compared to the National Science Fair that already has a history of over 20 years, the PowerTech Contest is relatively new and unknown to most of the parents and teachers. To acquaint and familiarize parents and teachers with the contest, multiple media channels were used and a consulting center was established to help promote the activity and provide all necessary assistance. The media promotional campaign was divided into two stages. In the first stage, reports plus advertisement were published in Mandarin Daily News whose main readers are elementary school teachers and students, and other print media such as promotional leaflets and direct marketing materials, were placed in technological-innovation-related social and educational institutions, including the National Museum of Natural Science, the National Science and Technology Museum, and the Science Education Center. All promotional materials included a brief introduction about the organization and implementation of the activity as well as the contact information. During the second stage, organizers started promotional activities, provided guidance on school campuses and established a PowerTech Contest Consulting Center to coordinate the handling of inquiries. In addition, the TCDA created a new column on its organizational Website to disseminate relevant information about the contest, including technological innovation teaching, FAQs, and online registration, in order to increase the visibility of the contest and the registration rate. Through these efforts, the number of participating teams grew exponentially from 78 in the first year to 414 in 2006.

**Figure 1. Power Tech contest flowchart**



***The problem of "Who has the willingness?"***

According to the theories of incentives (Rice, 2006; Baer, Oldham & Cumming, 2003), one would offer a "carrot" in front of a horse for it to move forward. Therefore, the PowerTech Contest organizers provided a free trip to Japan to see a robot contest (sponsored by domestic business enterprises) as the final prize. Also, officials from the Ministry of Education and National Science Council were invited to be award presenters at the award ceremony, which was also a great encouragement for the participants. In addition to student awards, teacher advisors were also given awards for their leadership and dedication. This was to encourage them to continue their efforts and to lead another team in future contests.

According to the equity theory, fair games promise chances to win, and the chances to win sustain the willingness to participate. In order to ensure the principles of fairness, justice, and openness, the PowerTech Contest required the participants to produce their product on site on the day of competition to avoid similar criticism on science fairs about the possible master-hand hidden behind the scene. For score calculation, the contest included the creating competition contest (60%), the modeling design contest which aims to encourage students to utilize their artistic talents and improve their command over aesthetic expression (20%), and the teacher advisor's innovation process record journal (20%), to ensure that teachers indeed participated in the process. As long as teachers are involved in the process, they are sure to gain something; and as long as they feel rewarded, they will be motivated to lead their students to participate in the contest.

Finally, according to game theory, an interesting game must also be competitive. The competition may be against time, against a rival, or against both at the same time. The PowerTech Contest not only upholds the principles of fairness and openness, the contest design, including the speed race, wrestling, and tug-of-war competition between participants' creative inventions, also imitates real, live human competition so that students can become highly involved and motivated to make improvements to their invention and to enter the competition again in the future to prove that their improvements indeed work better. Based on the three guiding principles discussed previously, it is believed that the PowerTech Contest will continue in the years to come.

## Conclusion

For a nonprofit organization to hold a sustainable activity in this rapidly changing society, and thereby fulfilling the missions and ideals of the organization, a process of strategic planning and managerial thinking as stringent as that followed by the corporate world is necessary. The core of the PowerTech Contest also lies in its ability to fulfill its educational functions and purposes. Next follow the conclusions of this study.

***Building a professional operation mindset to boost competitiveness***

The organizers of this nationwide contest successfully formulated and designed a creative activity that not only appeals to today's youngsters but also meets their demands for science education. In addition, the organizers have incorporated novelty features in the contest designed to attract students, and they have reviewed the effectiveness of its activity implementation throughout the whole process of design, development, and assessment.

***Shaping a professional image to lure new "customers"***

The PowerTech Contest has focused its public and media promotion efforts on building a professional image in order to increase its name recognition. Also, various new marketing approaches (regional integration, total marketing) were incorporated in order to create positive and effective word-of-mouth marketing via participating students, so that all the limited resources can be fully exploited.

***Extending the reach and scope by involving relevant institutions***

In addition to internal management strategies, the organizers also strengthened its partnership with external resources. For instance, the first three contests all collaborated with the National Museum of Natural Science and the National Science and Technology Museum and used them as bases for service team training and contest venues. Such cross-institutional partnership and collaboration further ensured an effective use of the limited operating resources of the contest.

Since there is still room for improvement in terms of general considerations and specific measures of the contest, the organizers will strive to make continuous improvements to ensure that technological creation can truly become a part of everyday life and that their countries' economic competitiveness will be further lifted as a result.

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