Cultivating Teenager’s Understanding of Magnetic suspension

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Abstract

The first commercial maglev line in the world started its operation in Shanghai on 31 December 2002. It became a hotspot event of significant scientific and social influences. Taking advantage of the intensive curiosity of the public, in particular teenagers, for this hi-tech project and its underlying scientific principles, Technological Instructing Center for Teenagers of Changning District (TICTCD) launched a scientific and technological communication campaign, centering on the subject of “Nourishing Teenager’s Understanding of Magnetic Suspension”. The purpose of the campaign is to make teenagers: (1) understand the scientific principles of the interplay of magnetic poles; (2) understand high technologies related to maglev; (3) attempt to research on and develop a model maglev train; and (4) pay attention to the positive and negative social impacts of science and technology.

Keywords: Teenager, understanding, magnetic suspension

Foreword

To boost students’ scientific literacy, relevant education should take the form of scientific research and practices, base its activities on students’ existing knowledge, and select topics of common interests in everyday life. Students should be made feel like a discoverer, researcher and explorer when participating in such activities, and experience the power of wisdom and happiness of creation. This kind of experience will further inspire students’ intensive love for science and enthusiasm for innovation, which is a precondition of the extensive and solid implementation of research and practices and a guarantee for a leap forward of teenagers’ exploring capabilities.

The first commercial maglev line in the world started its operation in Shanghai on 31 December 2002, which became a hotspot event of significant scientific and social influences. Taking advantage of the intensive curiosity of the public, in particular teenagers, for this hi-tech project and its underlying scientific principles, Technological Instructing Center for Teenagers of Changning District (TICTCD) launched a science and technology communication campaign—Boosting Teenager’s Understanding of Magnetic Suspension. The purpose of the campaign is to make teenagers: (1) understand the scientific principles of the interplay of magnetic poles; (2) understand high technologies related to maglev; (3) attempt to research on and develop a model maglev train; and (4) pay attention to the positive and negative social impacts of science and technology.

Process of Science Communication

After the operation of the maglev line, TICTCD designed a campaign for primary and middle school students:

Making use of the principle of the interplay of magnetic poles, prescribed magnetic materials and an air balloon and other materials selected by their own, participants are asked to make a maglev train. A speed race on the specified track and a show of the designing concept of the train will be held.

Phase 1: Initiation

1. Knowledge Point

Maglev utilizes the principle of the interplay of magnetic poles, which is introduced in textbooks for primary and middle school as “magnetic poles of the same polarity repulse one another; magnetic poles of the different polarity attract one another.” TICTCD thereby brought forward the campaign plan of simulating part of the working principles of maglev line and entitled the concept show and speed race “Future Vehicle—Our Maglev”, with OUR signifying this train was different from the real one.

2. Development of the Train

Based on intensive investigation, TICTCD organized participating students to trial-manufacture the train. We provided participants with different materials for them to evaluate and came to the conclusion to utilize low-cost, easily available materials well-known by participants and even scrap and discarded materials.

3. Drawing up Guidelines for the Campaign

Guidelines served as both an obligation and a guide for participants.

(1) Take the form of speed race: it’s best suited for fostering participants’ competitive spirits;
(2) Specify the status the train in motion: it’s best suited for participants to understand the basic principles of related hi-tech;
(3) Exert no limitation on the form, structure and weight of the train: it’s best suited for activating participants’ creative potential and improving their creativity;
(4) Encourage creative concept: it provided participants much room for innovation, which was best suited for inspiring student’s imagination.

Phase 2: Promotion and Communication

An extensive promotion and communication campaign was carried out in all primary and middle schools in the Changning District and all over the city, with the purpose of inspiring participating enthusiasm and in the form of presentation film, lecture, visit and handout. Participants, with their instructors’ help, listed all potential problems and made up a plan to solve the suspension, orientation and acceleration of the train one by one.

Listening—scientists gave lectures about the interplay of magnetic poles

Maglev is a hi-tech that involves complex technologies and abstruse theories. Participants held discussions with experts, Dr. Huang Jingyu and Shi Liming from Shanghai Maglev Transport Communication Co. Ltd., and learned the two development trends of magnetic suspension technologies. One is represented by German normal magnet attraction suspension system, i.e. the Electro Magnetic Suspension (EMS) system. It’s based on the basic principle that normal electromagnet and ferrous substance attract each other. In such systems, the train is levitated by about 10mm and its speed can mount to 400-500kph, ideal for long-distance intercity transportation. The other is presented by Japanese magnetic repulsion suspension system, i.e. the Electro Dynamic Suspension (EDS) system. It’s based on the principle of superconducting magnetic suspension and utilizes the repulsion between the wheel and the rail. In such systems, the levitation of the train is much more than that of EMS system and amounts to about 100mm, and its speed can be as high as more than 500kph.

Watching—TICTCD organized participants to visit hi-tech shows related to maglev and watch popular science films

Participating in Development—TICTCD held a speed race entitled “Future Vehicle—Our Maglev” to encourage teenagers to research on and develop a model maglev

A maglev is featured of appropriate gap between the wheel and the track, which can reduce the resistance endured by the train. However, what should be done to make the train suspended and move rapidly?

Participant carried out a lot of experiments to overcome these difficulties:

(1) Suspension of the train: Participants found that, to make the train levitated above the track covered with plastic magnetic seals, the bottom of the train should be covered by the same material, and its position should be parallel with the seals on the track. Due to the weak magnetic force of the seals, materials used to construct the train should be nonmetals of light density and high strength.

(2) Orientation of the train: Train covered with magnetic seals can be levitated. However, participants found, in the magnetic field, the train will swerve and be attracted closely on the track. Orientation equipment is needed on each side of the train.

(3) Acceleration of the train: Maglev is characteristic of low energy consumption and high speed. After overcoming the two difficulties above, participants strived to attain high speed. They did their best to find the optimal design after numerous experiments with the air volume and the size of the nozzle of the balloon. Some even installed a pressure vessel outside the balloon to increase its volume. Keeping the speed contest in mind, participants unanimously agreed that the train should take a streamlined shape.

Phase 3: Presentation

Contests were held to improve participants’ capabilities of deal with emergencies by their own, team working and communicating skills.

TICTCD held several lectures at various levels (twice at the district and three times at the municipal level); tutored instructors and students from other districts such as Jinshan and Baoshan; gave many presentations of this science popularizing campaign to missions of scientific and technological education from all over the country, such as an educational mission from Hangzhou, a mission of scientific and technological educators from Shandong, a mission from China Association of Teenager’s Scientific and Technological Instructors—to just name a few; and held one (1) presentation respectively for the municipal mission of key principals and instructors, and all primary and middle school students of the Changning District.

Phase 4: Participating in Discussion—Teenager’s scientific forums were held to explore and discuss the positive and negative effects of science and technology on the society, taking maglev as one such example.

Science and technology is the most powerful driver of social development. The development of science and technology is a two-blade sword, however, and has its pros and cons. A better understanding of this will benefit the teenagers—the master of the future. Participants brought forward many powerful arguments and the most significant included:

(1) The atomic bomb explosion over Hiroshima. Many renowned scientists including Albert Einstein and Julius Robert Oppenheimer proposed to the US government to develop atomic bomb. They originally intended to end World War II earlier and avoid the endless disaster

brought with a long war. What they didn’t anticipate was the horrible mass destruction and the consequent gene mutation would pass on for ever. The death of millions of people and the miserable life suffered by victims of gene mutation made many scientists in favor of the development of atomic bomb shift their stance and threw themselves into anti-war activities.

(2) *Silent Spring* written by Rachel Carson. In this book, the author tolls deterioration of the environment and warns that worldwide pollution is threatening the existence of human being on the earth and the earth itself. The author depicts a horribly silent spring without any bird hovering in the sky. People see only the advantages of organic chlorine pesticides, i.e. rapid effect and low toxicity; they ignore the deadly consequences of long-term accumulation—species extinction, breakdown of food chain, destroys of ecological balance and disease threats for human being.

(3) The invention of automobile. Automobile on the one side improves the efficiency of vehicles and the productivity of human kind, and it on the other side consumes a huge amount of energy and causes air pollution.

Participants thus realized: the high efficiency of magnetic suspension can save commuter’s time, and it’s a waste of resources when there is too few passengers due to its high costs.

Results and Comments

This campaign attracted 21,307 participants from 44 primary and middle schools in the Changning District, and received 132 designs. It provided the participants a good opportunity to access hi-tech and understand its basic principles. Due to the large population of participants, this campaign fetched wide attention and was later listed as a contest event in the Fifth Shanghai Youth Scientific and Technological Festival, which attracted about 100,000 teenagers from the 16 districts and counties all over the municipality.

Questionnaires showed a positive reaction of the participants: they thought the campaign improved their understanding of the scientific principles and technological knowledge related to magnetic suspension, inspired their exploring spirits, nourished their designing and practical skills, and made them more conscious of the impacts science and technology has on the society.

Media, such as Youth’s Science, Shanghai Science and Technology, Youth’s Science and Technology, Changning Cable TV, Shanghai TV, Changning Times, Shanghai Teenagers Scientific and Technological Education web, Teenagers Scientific and Technological Education web of the Changning District, gave much exposure to this campaign and caused a sustainable upsurge of interests in magnetic suspension technologies.

Several factors contributed to the success of this communication campaign. First of all, it had a clearly defined goal and its underlying content—magnetic suspension principles and technology—was a scientific and technological hotspot of significant social influences drawing teenagers’ interests.

Second, it adopted multiple communicating methods such as listening, watching, and participating in development and discussion that are in line with teenager’s cognition model, which is best portrayed by “I hear…and I forget”, “I see…and I remember”, and “I do…and I understand”. It’s teenagers’ participation that opens the door for their real understanding of science.

This campaign improved participants’ scientific literacy. With the instructions from their tutors, they experienced the whole process of scientific research and got a preliminary understanding of the nature of science. Particularly, participants had the following capabilities honed in this campaign:

1. Creative Capabilities

Both instructors and participating students had initially no idea of maglev train and there's much room for innovation. Participants and their instructors brought their imagination into full play and made many kinds of trains. Innovations emerged in many fields. Materials included KT boards, paulownia boards, foamed plastic and even music cassette boxes. Structure took different forms of tabulate, frame and box. Some looked like a plane and some were miniature of the real maglev. As for the orientation wheel, it ranged from lathed metal wheel, idler wheel of model 4WD car, plastic writing cushion, ball pen refill, bearing in music cassette, Chinese chess to elastic fine steel wire. The variety of the works of the participants embodied the full exertion of their creativity.

2. Exploring Capabilities

The rationality of innovation should be tested in practice. We thus provided participants with much room for exploration and experiment.

Contest guidelines had no limitation on materials used for the train and participants found, after many experiments, the train should be neither too heavy nor too light, because it had only one balloon as its driving force. If the train was too light, the distance it could move by inertia would be too short; if the train was too heavy, the initial driving force would be too small. Participants achieved their weight goal of the train by adjusting its materials and structure and shortening magnetic seals.

3. Problem Solving Capabilities

During the training, participants found that the balloon would drift in the opposite direction for the resistance when the train reached a certain speed, which would hamper the acceleration of the train. To deal with this problem, participants carried out many experiments and installed a bracket or elastic strips on the train, achieving ideal results.

4. Expressing and Communication Capabilities

Contest served not only as a test of researching findings, but also a platform for participant to communicate and learn from each other. Familiar or not, participants would gather to exchange their feelings and findings. Students from Songhong Road primary school even improved their model according to advices given by participant from another school.

5. Information Assimilating Capabilities

This campaign involved not only basic principles of magnetism, but also was related to other knowledge such as aerodynamics and mechanical structure. Participants were required to combine all the knowledge as needed. At the same time, they should collect information about success and failure and adjust working plan accordingly.

Discussions

A suitable carrier is critical for the implementation of all-round education, whose focus in fostering innovation spirits and practical capabilities. A learning style featured of active exploration emerges, which is expected to overcome the improper trend of deviating from true life and overemphasizing the infusion of knowledge.

1. **Inquiring learning should base on students' independent and exploring learning, and emphasize on the integrated application of knowledge in multiple disciplines.**

This kind of learning should select and decide on research topics from students' everyday life and social life, and take the form of cooperation between individuals and groups. During this learning process, we require students to acquire new knowledge and, more importantly, to learn the methods of scientific research, develop the habit of independent and cooperative learning, and improve the capabilities of exploration and innovation. W. Suchomlinski, the late Soviet educationist, once said: “During the practices, students will feel like a discoverer, researcher and explorer, experiencing the power of wisdom and the happiness of creation.” This profound experience will further inspire students’ intensive love for science and enthusiasm for innovation.

As one of the important event of the Fifth Shanghai Scientific and Technological Festival for Teenagers, the “Our Maglev” project opened up an ideal opportunity to implement inquiring learning. By organizing students to participate in this campaign, we vividly witnessed the fun enjoyed by students taking part in inquiring learning and their innovative spirits showed therein.

In Phase 1, our primary purpose was to create an appropriate environment for scientific innovation, inspire innovating motivation and emotion—in other words, to give participants various experiences. It would be useless if we required students to bring forward an “Our Maglev” solution before they had concrete experiences. Students used Internet to access relevant technological literatures and understood the principle of maglev line. However, they were quite confused about the profound implications of these literatures and became worried about the possible difficulties. To help them overcome these feelings, instructors developed, with these students, a simplified maglev for a concaved track. It simplified the principle of magnetic suspension to the most basic one: “poles of the same polarity attract each other and poles of the opposite polarity repulse each other”. Furthermore, the task was proved attainable through magnetic force experiments. Even though the concaved track used here was different from the T-shaped one would be used in the contest, it didn’t hamper the interests of students to participate in the “Our Maglev” research.

In this phase, hands-on demonstrations were adopted to reveal the conflicting phenomenon, i.e. the disharmony between scientific phenomenon and student’s existing cognitive mentality. Students became surprised and shocked by the facts and truths presented before their eyes. Thus, their curiosity about and desire to explore the mysteries of the world were fully inspired, which led to an upsurge of excitement for exploration, which in turn inspired students’ motivation and motion for innovation.

After students experienced the exploration of certain phenomena, we started Phase 2—drawing up action plan and designing.

It’s critical to give students feedback on their design concept before they begin real exploring. We discussed the concept with every group before it’s put into implementing. If the concept was somehow defective, instructor would point out all the potential difficulties and facilitate the students to overcome them. However, if the students were determined on the concept, they were encouraged to pursue it.

After the feasibility study, participants began drawing up action plans and shared them with other groups. Instructors also took part in such sharing to get feedback.

The 3rd phase was researching itself—implementation. Participants had little help in this phase. The commitment of the students proved that inquiring learning is valuable. They expected and needed little help from instructors, which really surprised us. Their intensive interests in the task made it very easy to manage the classroom. Students could make choices on their own. So, they felt being respected and empowered. During their exploration, instructors would walk around the classroom, inquire about their tasks and share their findings. Students made use of all materials available—including timber and magnetic bar offered by instructors, and ball pen core, discarded music cassette, pulley on model car, pin, KT board and foamed plastic board selected by their own—to manufacture the train. And the train took a wide variety of shapes.

2. **A democratic educational environment is the paramount objective premise to tap student's creative potential.**

Creation is featured of openness. To encourage creation, we should make enough room for students to use their imagination, so that they can think, image and inquire freely. Student's creation should be given appropriate guide and vigorous encouragement. Their unconventional thinking should be encouraged. Even if students have conception that's most likely wrong, they should be encouraged to test it instead of being simply denied. It's the only way to fully tap student's creative potential.

The last phase was summarization. Students were informed that all scientists would report their findings. The classroom was turned into a contest arena where participants were required to manufacture their maglev trains and report to other participants their researching processes, i.e. to show their research reports—some even made multimedia presentations. The classroom was permeated with the enjoyment of hands-on research; failure or success in the contest became a minor issue. For the purpose of nourishing creative qualities, the process is much more important than the result of the activity.

3. Scientific and technological activities are a practice for exploring the unknown. In the process of inquiring learning, they require students to integrate theoretical knowledge with reality, find the right problems, have rich association and bold imagination, and find a flexible and genuine solution to the problem. The creative thinking of the students will thus be further honed, because the enjoyment acquired from the successful solving of the problem and the consequent intensive interests will arouse enormous inner drive, which will inspire a strong creative sense, and facilitate the formation and development of creative thinking.

We also came to understand in this campaign that, to be a qualified scientific and technological instructor, one should boast not only rich relevant knowledge, practical skills, and the capabilities of designing and organizing activities, but also strong creative thinking and capabilities. During such scientific and technological activities, neither what students will learn is genuinely creative, nor is the problem they will deal with unsolved by human being, but they are new to the students. When learning the knowledge and solving the problems, students will vividly have their capabilities of utilizing the knowledge, and the novelty and originality of thinking vividly displayed. When asked to learn by rote, students would think it too vapid to learn anything. Failure to reveal the internal connections between the problems will deprive students of their thinking process of exploring, imaging, analyzing and judging. If things continue this way, student's enthusiasm for learning and their creativity will be hampered. Therefore, despite the advantages enjoyed by scientific and technological activities in nourishing creativity, a lack of instructors with creative spirits and a tolerant environment will suffocate student's enthusiasm for creation and their creativity.

Student's creativity is essentially in existence instead of being instilled by knowledge. The ultimate purpose of inquiring learning is not to teach recipients abstruse knowledge but to tap their creative potential. And overly specific and profound knowledge will hamper tapping such potential.

Furthermore, students should be regarded as the subject of inquiring learning. All such activities should be centered on students; the role of instructors is to encourage, motivate and guide the students, and help the students in realizing their conception. As for the specifics, students should be encouraged to try freely. The principle of independent selection of subject, independent designing and independent implementation must be adhered by and instructors should restrain from butting in, so as to nourish the scientific method and creative spirit in students.

Conclusion

1. Scientific practices are an important carrier of improving student's scientific literacy. The subject of such activities should in line with the psychological characteristics of students and keep up with social hotspots. Researches should be based on student's existing knowledge. The design of such activities should make enough room for students to innovate (when drawing up activity guidelines), explore and experiment (when implementing the working plan). Materials used in the activity should be cheap and easily available. Only such activities can be widely accepted by students and inspire their enthusiasm to participate. And only in this way can they become the subject of the activity and have their scientific literacy improved.
2. Scientific practices emphasize on nourishing student's understanding and capabilities of scientific exploration instead of the failure or success of the contest. Such activities also shifted instructor's thinking. They consciously took into account the real conditions of their students and tried their best to inspire student's interests in exploration, so as to attract students to take part in such activities.

Take Mr. Shen Man, an instructor from East Yan'an Middle School, as an example. He found that, in the initiation phase, it would end up with nothing to ask students to bring forward an "Our Maglev" solution before they had concrete experiences of magnetic suspension. At this point, instructors should suggest students to search and read relevant literatures to understand the principles of maglev. When students became confused about the profound implications of these literatures and worried about the possible difficulties, Mr. Shen helped them develop a simplified maglev for a concaved track. It simplified the principle of magnetic suspension to the most basic one: "poles of the same polarity attract each other and poles of the opposite polarity repulse each other". Furthermore, the task was proved attainable through magnetic force experiments. Even though the concaved track used here was different from the T-shaped one would be used in the contest, it didn't hamper the interests of students to participate in the "Our Maglev" research.

During the manufacturing of the train, instructors changed the traditional teaching style of demonstrating and imitating, and adopted the style of nourishing student's exploring capabilities and scientific method. For example, Mr. Xu Jun from Jichang Middle School advised his students to clearly define all the possible problems before they drew up a plan. After the formulation of the plan, instructors would point out all the potential difficulties and facilitate the students to overcome them. However, if the students were determined on the concept, they were encouraged to pursue it. Instructors fully respected student's ideas and played the role of as a servant when the students were manufacturing the train.

Before the presentation at the district level, a qualification contest was held in every school. Such contests imitated the form of scientific forum and turned the classroom into a contest arena. In this arena, students were required to attend the speed race and report to other participants their researching processes, i.e. to show their research reports—some even made multimedia presentations. The classroom was permeated with the enjoyment of hands-on research; failure or success in the contest became a minor issue. For the purpose of nourishing creative qualities, the process is much more important than the result of the activity.

3. The distinctive characteristics of instructors make them individual players, for the isolation between campuses hampers the mutual understanding of many instructors—this phenomenon is even more significant other educational facilities. However, scientific practices involve many issues ranging from selection of subject, experiment, feasibility study, computer knowledge, researching method, organization and coordination, and knowledge structure. And it's hardly possible for a single instructor to accomplish all the tasks.

This campaign involved many tasks such as the overall designing of the activity, organization and implementation, preparation of equipment and material, and external communication. We had a clear division of these tasks and a decentralized decision system—delegating the decision-making to the most sophisticated experts, which guaranteed decisions were made by those who knew the situations best and brought the synergy effect into full play. In this campaign, teamwork spirits were best embodied by the excellent combination of partial and holistic tasks, and short-term and long-term interests. When striving to accomplish their own tasks, instructors bore the big picture in mind all the time and put the holistic plan and long-term interests over the partial plan and short-term interests.

An instructor said after the completion of the campaign: “Scientific exploring activities demand group wisdom. Individualism is no longer the right way. And there should be cooperation between instructor and instructor, instructor and student, instructor and student's parents, student and student, and student and his/her parents.”

4. The campaign provided participants with satisfaction and excitement, and effectively inspired their learning enthusiasm. It greatly improved participant's qualities and capabilities from multiple aspects. It also closely integrated scientific learning and applied creation, and theoretical knowledge and practices.

Different from the traditional learning styles that focus on impartment and textbook knowledge, scientific practices emphasize more on the learning process and borrow the researching process used by scientists. This is the only way to guarantee students will experience the whole activity firsthand and perceptual knowledge can grow into rational knowledge in according to the rule of “from perceptual to rational”.

At the same time, scientific practices also emphasize results—educational meanings with respect to capabilities, knowledge and moral culture, not the simple pragmatic meanings.

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