

A Method for Identifying STEM Gifted and Talented Youth

: development of mentoring approaches

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Finding the diamonds in the rough

Provision of specific education programs for gifted and talented students in science and technology is one major strategy that many eastern and western countries have adopted to facilitate and induce leapfrogging of technical and economic development. High caliber scientific personnel of critical mass underpin a new paradigm for driving socio-economic changes. Thailand recognizes the potential of gifted and talented students in science. Many projects on gifted education have been implemented for more than two decades. The terminology 8gifted and talented students: were first used in 1984 in the Thai education system under the Project on Development and Promotion of Gifted Students in Science and Technology (Por-Sor Wor-Tor), under supervision

of the Institute for Promotion of Science and Technology (IPST). Arising from the decline in study of science and falling numbers of science students, the Por-Sor-Wor-Tor Project was launched to attract students with potential. This was followed by participation of Thai students in Mathematics and Science Olympiads in 1989, concurrent with selection of students having outstanding academic performance by the Foundation for Promotion of Academic Olympiads under the patronage of the late HRH Princess Galayani Wattana. These three activities were coordinated by IPST. In 1998, the National Science and Technology Development Agency initiated the Junior Science Talent Project (JSTP) with universities, based on mentoring of students by university staff and researchers.

The JSTP aims to increase number of competent children in science in Thai society by continuously working with the best candidates on science projects under the supervision of mentors. Selection of students is done at lower secondary school level (Grades 7-9), higher secondary school level (Grades 10-12) and first year university, based on nomination by schools and parents and students themselves. Researchers and scientists of national repute are invited to serve as mentors to the children, which has not been done in other programs. KMUTT is responsible for the lower secondary school intake. It should be noted that over time KMUTT has developed a wide range of activities through partnerships with other universities, including of Chiang Mai University, Walailuk

University, Kasetsart University and Suranaree University of Technology. Nation-wide selection is carried out through interviews by the mentoring team, taking into consideration education and other achievements, student portfolio and interviews. The selection ratio was originally varied from twenty-to-one to ten-to-one. Three one-week enrichment camps are conducted in May, October and April and during long-weekends, some workshops are added. Activities include open-ended experiments, field trips (dealing with industry, environment, arts, history and culture), competitive intellectual games, special lectures and the Constructionism learning methods. Additionally, individual science projects of about 9 months duration are conducted under guidance from the mentoring team or

otherwise invited expertise from other universities and research organizations. Observations and identifications are made by the mentoring team on student performance and potential. Throughout the period, creativity, learning and general behavior characteristics are identified through the abovementioned activities. The best fit 3-5 students are awarded scholarships from the National Science and Technology Development Agency (NSTDA).

Selecting the best

What is described for the selection process here encompasses only the JSTP for students at lower secondary school level (Grades 7-9). Importantly, all the mentors are research scientists/engineers in either the university or its network - they are neither educators nor teachers. But who were the gifted and talented? The term was so new in Thailand in the early 90's and was very broad and encompassed different characteristics and strengths. A report by the US Department of Education, listed five broad areas in which giftedness could reveal itself; general intellectual ability, specific academic aptitude, creative or productive thinking, leadership ability and visual and performing arts. The broad definition means that no single program could possibility meet the diverse needs of everyone identified as gifted and talented. Therefore, the implementation paradigm has been made to mentoring-based activities. The JSTP method can be categorized into three components; recruitment and selection, enrichment camp and research project.

Recruitment and selection process

Students complete an application form that is comprised of three main parts.

1. Academic background: student grades are not big issues in the application, however they can transparently show the student's progress in his/her academic career. The reviewers are also interested in seeing the student performance in non-STEM related fields, in order to see the special interest in student. In addition, information about the school reflects the student's background and environment, which will help the reviewer form the interview questions for the next round.

2. Portfolio: the reviewers are not looking for the outstanding awards that the student may have achieved, but rather the scientific mindset that was used in each project. The reviewers are interested in seeing the development of the student's ideas and thinking methods that might be reflected in the descriptive portion of the portfolio.

3. Interest and perspective toward STEM fields: the student's are asked to identify their idyllic scientist, their favorite innovation and tell the reviewers about their passion and dream career. This part will help the reviewers understand the student's attitude toward science: whether it is something that the student wants to do, or something that was constructed in the student's mind by their parents and teachers.

Beside the profile information in the application, the students are required to answer a number of open questions. These questions are rarely related to the standard school curriculum and instead they challenge the individual to imagine and seek for the endless answer that has no right and wrong answer, thus providing equal opportunity for students in the urban and country areas. The main point for having the questions is to furnish an opportunity for the students to demonstrate their natural way of thinking on the unseen problems. Here are some examples of the open questions:

Some questions require students to purely use their imagination to come up with the abstract idea and to demonstrate how they arrived at that idea.

“How would a song that both humans and aliens could enjoy sound like? Why?”

JSTP 2016 Application

Some questions ask students to show the logical thinking by roughly developing the formula that can calculate something that is difficult to do so. This kind of question demonstrates how well the students can identify and see through the connection in nature.

“Please discuss how would you calculate the volume of a cloud and the water within it?”

JSTP 2016 Application

Some questions involve cultural and social issues, which require students to think outside of the classical sciences and take human and societal factors into account.

“Please discuss how would you design the place for people in your community to live for next 10 years, 500 years, and 1,000 years?”

JSTP 2015 Application

“The floating lantern festival is one of the most famous tourist attractions in Thailand. However, there are numerous houses that are damaged by the lanterns every year. As a scientist, how would you solve this problem?”

JSTP 2015 Application

Some questions require students to draw or draft something, which demonstrates how they articulate issues and re-synthesize them in their own way.

“How would you draw a two dimensional symbol to communicate with an intelligent extraterrestrial life form that contains the following message: Humans have 2 biological genders: male and female, the average human height is 170 cm and weight 60 kg, humans come with peace”

JSTP 2015 Application

In the review process, the reviewers would break down into small groups including at least three of them with variance in research area and viewpoints. Each group would discuss and select 20-25% of all applications to present and discuss with the entire review panel. This process helps the new reviewer to understand the process and would be beneficial for the students in that their applications have some doubts for the reviewer. The average time that the team of reviewers used to review the assigned applications is about 100 hours.

For the interviewing process, the reviewers split into subgroups and travel to each part of the country to conduct the in-person interviews. The locations for the interviews are local schools, or universities. There are two processes during the interview. Students will firstly need to solve the experimental challenge by using the given tools and objects. The questions are open-ended like the questions in the application and do not require any advanced knowledge. This process tends to calm the students down and provides time for them to compose some notes for the reviewer to see during the interview process.

During the actual interview period, there are 3-5 mentors per one candidate. The questions during the interview are different between the student in the urban area and in the country area. For the urban students, the questions are more particular on the scientific advancement and the cutting edge discoveries. The reviewers would have a relaxed conversation with the students on such topics and see how that student would react by asking questions. For the students that come from the country area, the questions would be on the nature that the students observe in their area. The reviewer would be interested in seeing spatial intelligence, which is the ability to see the relationship between space and time. Beside those questions, the reviewer would talk through the student's interests, life goals, prior science projects and other questions in the application

to understand the student as a whole. At the end of the interview, the peers request the candidate to ask any questions because generally in the Thai education system, questioning is likely to be prohibited.

Between 30-50 candidates are selected, which is about 5% of applicants.

Enrichment camp

In order to enrich the future generation of innovative thinkers, the implementation process needs to be innovative as well. The JSTP method is an iterative process that keeps evolving from the observation of the students that join the program. The processes of the JSTP are designed around the principles that science is not a subject: it is life, society and surrounding, which means the program is targeting the youth that are passionate and curious about science and nature.

Three enrichment camps are usually managed during the semester breaks and each last for 5 - 7 days. Activities can include field trips, hands-on experimental challenges, presentations, evening lectures and recreation. The camps cover diverse areas – the creative arts, humanities, history, science and technology, innovation and leadership development. Ten to fifteen mentors join them, plus alumni. The camps are unlikely to relate to the formal curriculum in order to reflect the philosophy that science is not a subject.

Each university in the network country takes a turn in hosting the camp and using their local resources to enrich and expose new experience to students that are from different places. The theme of the camp is considered by the question "What topic would make the student curious the most?" Once the theme is set, the camp organizer would reach out to the knowledge resources in the area, including any research group that is doing an exciting experiment in the area, the local museum or place for field trip and the community that has a traditional practice. The camp organizer will talk to each group and discuss the expectation for activity that they will setup for the students. The main goal for these experiments is not to force student to learn new information, but to create an environment that inspires the students to think critically outside the box, enjoy questioning and exchanging thoughts freely. This way the students absorb not only the knowledge, but also the culture of curiosity.

The field trip session is usually the first activity in every camp. It mostly gives context and background information to the rest of the activities. The locations for the session vary from the cutting edge biological engineering lab to the art museum or the ancient temple. Often, the camp organizer would tie the location to the theme to the camp, but sometimes it is just done in isolation. Once the students are at the site, they would split up into subgroups with the

random mentors. The goal of this session is to expose students to the new environments and experiences to make students open their mind in order to start absorbing and thinking through new materials. At the end of the field trip, there might be a small reflection or lecture to discuss the new knowledge that both mentors and students learn.

Hands-on experimental challenges usually come after students learn some context and basic knowledge from the prior activity. This session is designed specifically to challenge students to make or design something for an open-ended problem. Some examples are:

- “To make a robot that mimics an organism that lives in the mud, in order to transport 3 kg of given mass”
- “To come up with ideas on how do people in the past live, based on the given archeological field”
- “To design a plant that is the most effective engineered plant”
- “To investigate why the fermented fish is sour”
- “To make a flying balloon robot that can win the robot war”
- “To design a biological circuit that does something”
- “To design a solution that improves the quality of life of people around the university campus using social media”
- “To make a machine that can draw with a laser”
- “To develop an

application or software that utilizes cultural material of Thailand”

When a challenge is given, the students would split into small groups based on the combination that the mentors wish to see. This give students a chance to interact with new people that might have the same or different interests, which will help students further their perspective and worldview. This hands-on session has no right or wrong solution to it, which means the students have unlimited possibilities in expressing their thoughts and imagination, thus promoting play and joy in students which is the most important way for them to learn. During the activity, the JSTP alumnus and the mentors would serve as facilitators when the students are brainstorming, this process providing an opportunity for the mentor to learn the thinking style and the inside of each student. The camp would also include a single big challenge or a couple of small challenges. After the challenge is over, each student group has to give a presentation to the entire camp. This way the students will learn other group ideas and have the chance to ask questions, discuss and exchange ideas. The mentor would also interact with each group by questioning and encouraging students in a positive way. The goal of this session is not to find the best solution, but to have each idea heard. It is also very important for students to explain the way that they have come up with the solution in order to develop critical re-thinking and communication skills.

Evening lecture or talk is the session that are mostly conducted at the end of the day. After the students are tired with the activity during the daytime, lecture session serves as a relaxing period for the students to have some food for thought before they go to sleep. The camp organizer would usually invite a person that the students find interesting to interact with, to come and give a presentation for each night regardless of the relevancy of that person to the camp theme. The mentors are expecting to see not a Thai classroom environment, where there is no interaction between the lecturer and students, instead the mentors want to see the development of ideas stimulated by the given presentation.

Recreation serves as the session for students to develop a deeper relationship with other students, alumni and mentors by playing sports together. The activities usually range between sports, cycling and music.

Science project

Another integral part of the enrichment camp is an individualized science project. The project is based on the students' personal interests, and develops essential research and presentation skills. The approach of the project can be from discovery to theory, as long as it is original to the student's curiosity. The students are paired with a specific mentor to nurture their curiosity while working on the project. The goal for the JSTP project is not to force the student to do something that is regarded as professional and has a desirable output. Instead, the goal of the JSTP is providing the student with an opportunity to have fun and be able to pursue his/her passion. The mentor that works with each student would not focus on the result of the project, but on bouncing ideas and questions with the students in order to help the students develop critical thinking.

At the end of the one year programs, the students would present their project to all stakeholders including mentors, alumni and friends; thus giving mentors and other students chances to ask questions and give suggestions to the presenter and lastly to observe or even identify the merit of the work and personal characteristics. Each student will have approximately 5 minutes to talk. This kind of activity is rare and students gain an experience beyond the formal education system, that the ultimate power belongs to the teacher, which sometimes make the students uncomfortable to present their views. However, the constructive criticism would help the students improve their communication and presentation skills.

It doesn't stop there

The JSTP actively pursues new innovative programs to enrich the gifted and talented students by organizing the science camps, giving students the opportunity to pursue their passion through motivation driven research projects and creating a community of senior STEM scientists, professors, researchers and students to cultivate lifelong mentorship. Within the philosophy that science is not a subject, but it is life, society and surrounding, the JSTP is not forcing students to learn the hard concepts of science like traditional enrichment programs usually do. Instead, the JSTP focuses on the process not the output, which results in activities that are challenging students to think critically about the given open questions and giving students opportunities to play with the scenarios and tools to come up with the solution, as the research shows that play is the natural way for humans to develop intelligence.

Once the student has completed the one-year program of JSTP by attending science camps and presenting their project at the end, those students become JSTP alumni. Unlike other programs that mainly focus on the current problem, JSTP also aims to enrich those alumni as well. In the activities, the mentor and alumni would work closely together to facilitate the critical conversation in almost all activities, thus giving opportunity for the alumni to play a

passive leadership role by leading a group of JSTP newcomers, but not directly guiding them. JSTP alumni always keep the close relationship with the mentor that they work with and this results in lifelong mentoring.

In addition to the benefit that the JSTP is constantly producing critical thinkers through the enrichment program, JSTP itself becomes the innovative solution, covering enrichment camps, open-ended process, project based learning and a sense of community. The JSTP's implementation creates not only future academic scholars, but a wide variety of alumni in different career paths. This results in an interdisciplinary community that shares the same core value, which is the scientific mind. This group of JSTP alumni are change-makers in their own way and their working life which are manifested in the Alumni Development Program every other year.

The JSTP organization is decentralized and a dynamic organization. It is driven by mentors and alumni which helps JSTP stay fresh, relevant and continuing to be innovative. There are increasingly a number of activities and workshops in the JSTP camp that are designed by JSTP alumni. The implementation paradigm of JSTP (science is fun, lively and playful) is conducted in all levels of the organization, there is no linear power structure in

JSTP which helps the organization evolve rapidly by the processes of reflection and idea bouncing between people from different generations (mentors, alumni from different fields) without boundaries.

It is apparent from past successes that the future of the JSTP is crystal clear. The interdisciplinary approach of the program that integrates liberal values to the activities is gradually helping to transform Thai science, technology, engineering and mathematics into liberal education, which focuses not only on the core information of the subject, but also focuses on the surrounding context and the bigger picture of the issue. For the future JSTP will be also be pushing to create a student that understands the concept of technology startup, which will help them be successful in the future globalizing world.