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Gifted Children Education in Science: How do Gifted Children Develop Scientific Creativity

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What kinds of human resources will be needed in the 21st century?

What are the necessity and purpose of the gifted children education? What kinds of talents shall be nurtured through the education?

It is listed in the following seven individual virtues demanded in the 21st century. The virtues will contribute to the happiness of the individuals and be called 7C's by the author. The first C means the competitiveness that is needed in competing with others; the second C cooperation; the third C compromise; the fourth C means responsibility for one's faults; the fifth C credibility; the sixth C creativity; and the last C signifies servant leadership. It is sure that individuals equipped with these qualities will be welcomed by the new age.

It seems to be very difficult for a child to be equipped with all of those qualities. But it is possible that scientifically gifted children will be equipped with all of those qualities when the education for those children is conducted in an appropriate way; it is possible when various thinking and research processes are repeated; it is possible when small and easy concepts of science shall be tackled first; Science gifted children develop scientific creativity

What kinds of human resources will be needed in the 21st century? When considering the need for the special education for gifted children, we usually think

of individual needs and national needs. However, the two kinds of needs should and can be accomplished at the same time. In other words, individual desires can be satisfied at a same time when individuals are contributing to the nation, and vice versa. Then, what are the necessity and purpose of the gifted education? What kinds of talents shall be nurtured through the education?

I would like to list the following seven individual virtues demanded in the 21st century. The virtues will contribute to the happiness of the individuals and be called 7C's. The first C means competitiveness that is needed in competing with others; the second C cooperation; the third C compromise; the fourth C charged means responsibility for one's faults; the fifth C credibility; the sixth C creativity; the seventh C challenging; and these C's signify servant leadership. It is sure that individuals equipped with these qualities will be welcomed by the new age.

It is not easy for a child to be equipped with all of those qualities. Being equipped with all of the qualities may be more difficult than being good at all the schools subjects such as Math, Language, Science, Arts, and Gymnastics. But I think it possible that scientifically gifted children will be equipped with all of those qualities when the education for those students is conducted in an appropriate way.

1. It is possible when various thinking and research processes are repeated.

Theories of modern science education inform that science study should be started with 'scientific knowledge' and 'scientific inquiry process.' The former include knowledge about Physics, Chemistry, Biology, and Earth-Science, etc. The latter include various skills needed to approach science---identification of problems, set-up of hypotheses, verification of hypotheses, experiments, observations, control of variables, performance and analyses, deriving conclusions, generalizations, and applications. The inquiry for scientific knowledge using these skills should be conducted in the process of scientific thinking. In other words, one needs a scientific recognition process that joins together creative thinking, analytical thinking, and critical thinking. The inquiry for scientific technologies in the process of scientific thinking naturally leads to the curiosity about science and

contributes to scientific attitude. As a result, one can understand what is science or the nature of science and escape from scientific ignorance (accomplishing scientific literacy). This is the theory of modern science education. It is wrong to regard that such theories have been established only recently. One of the old classic books of Confucianism frequently referred by Oriental forefathers also mention the theories related to scientific education. The book touches rather seriously and separately such questions as what is studying science or what kind of attitude should a scientist have? It seems definitely necessary to revert to the scientific thinking of the old sages even in these days when the preference for science and scientists is being gradually reduced. How the importance of science education was stressed in the past can be proved in one of the Seven Chinese Classics named by 'The Great Learning (大學)'.

The Great Learning says that one who wishes to cultivate his morals, rule his family, govern a country and then control the world should thoroughly establish his knowledge and then set up faithfully his will. What does it mean to establish his knowledge? It means investigating objects. The Great Learning calls it 'the study of things and nature (格物),' in other words, 'doing science'. That is to say, the cognition and attitude of doing science are the bases on which one shall cultivate his morals and then rule his family and then govern a country and then rule the world.

In the subsequent chapter of 'the study of things and nature leads to their knowledge (格物致知),' more concrete discussions are conducted on what kind of cognition and attitude one should have to study science. The discussions are developed in the following manner: "The object of scientific study and research is nature itself, and scientific thinking should be started from the scientific laws and theories already learned. At first, only the knowledge already acquired is applied, but later one can reach a new scientific law or theory when he has repeatedly conducted the process of scientific thinking and research. Moreover, science is not learned in a short period of time but can be understood only after repeated training in various thinking and researches. One can understand the nature of

science and his knowledge will be firmly established only after he is able to apply science to his everyday life.”

The sages made the most of science, but nowadays less people are challenging science as time goes by. It is probably because they regard science as a very difficult field in its essence. However, science is easier than any other field when one can feel science in his mind. Based on the knowledge already acquired, one only needs to think over and over again in a scientific way. You need not memorize difficult and complex formulas. After all, why is it that the old sacred books of Confucianism, which make relatively light of practicality, mention the need for science? It is because that science comprises all kinds of thinking such as logical, creative, and critical thinking as well as varied techniques to seek for such thinking. As a result, in science, it is easier than in any other fields to raise problems and find solutions. The complex society of today has many problems whose answers cannot be found. Arduous works to find out an answer do not guarantee a solution. In contrast, it is relatively easy to find an answer to a scientific problem. Contemplation shall lead to an answer in any way. Accordingly, scientists have felt a great sense of achievement and motivation to continuously pursue scientific studies.

I think that faithful learning of science will surely lead to the achievements in almost all school subjects. A few years ago, it was popular to suffix 'science' to a subject name so as to come up with such titles as 'social science' and 'human science.' Why was it? It seems that scientific methodology should secure a correct and trustworthy way to a study of the society and men. Social science and human science want to competitively use a scientific method and actually use it. In like manner, most of research processes and methods for science may be applied to almost all the other fields that pursue and create knowledge. Science can be a steppingstone providing easy access to other subjects.

2. It is possible when small and easy concepts of science shall be tackled first...

The study of science should be started from small and easy concepts that are

at hand now. You need not acquire new knowledge before studying science. The following examples will help you understand it.

It is an experiment to draw the orbit of Venus using its maximum elongation and it is suggested in a middle school textbook. What is the maximum elongation? It is the angle when Venus is separated farthest away from the sun. The picture describes a circle representing the orbit of the earth and is drawing the orbit of Venus using its maximum elongation. An excellent and thoughtful student can think of a new problem while drawing the orbit of Venus. Nowadays, many students have startling imagination because they have read many books. Such students may remember that the orbit of a planet is elliptical. But here, the orbit of the earth is a circle. Why is it? Does the textbook say something wrong?

We must begin dialogues with students in here. Contemporary children will answer any questions quickly. However, they are dumbfounded in front of such questions as 'How did you get the answer?' For example, in mathematics, π equals 3.14. Almost every student knows and memorizes it. But they are confused and perplexed by such questions as why does π equal 3.14 or in what way was the value of 3.14 acquired? They retort the question in this manner: That π equals 3.14 is a truth and why do you make a question about it?

Students of the Science Gifted Education Center under the Seoul National University once visited a special-purpose high school. At that time, a teacher from the school asked them a question: How many stars are there in our galaxy? No answer. Then, the teacher blamed their ignorance and said there are about 100 billion stars. One student raised his hand and said, "To us, the number of 100 billion stars is not so important. We are now wondering how did the 100 billion stars come out." The students were not so inquisitive at the time they came to the center first. Ordinary students are focused on the number of 100 billion. But Science gifted education changes the students. Why is that? They often make a question into what did bring about such a result? The educational system for nurturing scientific talents has changed the students because its

repeated scientific inquiry process enables them to acquire new knowledge based on already learned concepts.

Scientific Activity: Deciding the orbit of Venus

adapted by a middle school textbook

Things to prepare:

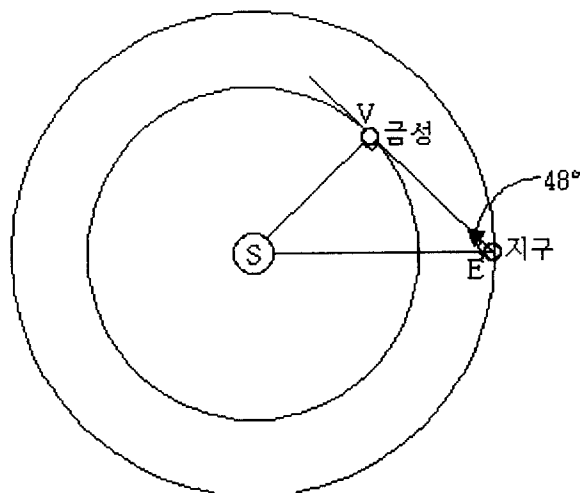
protractor, paper, ruler (30cm), and compass

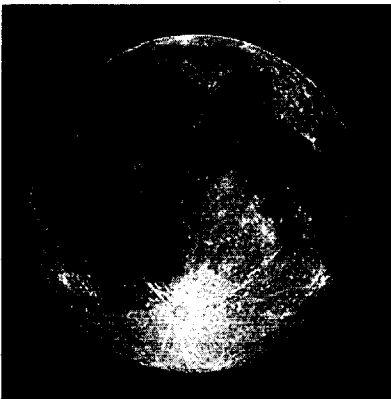
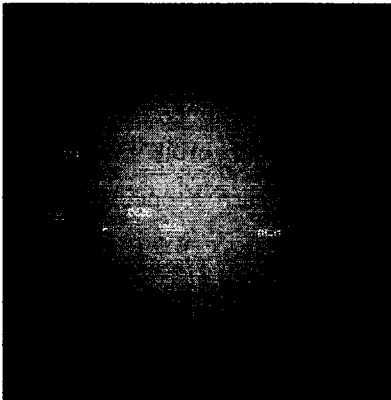
Procedures:

1. Draw the 10cm line SE on a paper, and then using the protractor draw another line from E whose maximum elongation is 48° .
2. Draw a vertical line from S and call the intersection point V. Making S the center, draw a circle whose diameter is SV. This circle is the orbit of the earth.

Explanation and result:

1. Let's the distance between the sun and the earth be 1. Then, how long is the radius of the orbit of Venus?
2. How far is it from the earth to Venus when Venus approaches the earth the most?





Let's return and think about how to confirm if the orbit of the earth is a circle. It should be first considered in the education for scientifically gifted children, if it can be sufficiently proved by the knowledge a middle school student already has. Middle school students should study science using their own knowledge, not the concepts possessed by graduate school students or doctoral degree holders. In the latter way, their scientific quests will come to nothing. As is stressed in the Great Learning, science must begin with what we have already possessed and what we have already known.

It is much easier than thought to confirm if the orbit of the earth is elliptical. There is a fact both elementary school students and kindergarten kids know. When taking a picture, they understand one should stand in front if one's height is short and stand at the back if the height is long. Even a child knows the fact that an object looks bigger when it comes more to the front and smaller when more to the back. Based on this principle, you need compare the sizes of the sun earth's revolving around the sun in the pictures taken at various points of its orbit. That is to say, if all the sizes are the

same, the distance between the earth and the sun is constant no matter where the earth is. That means that the earth revolves around the sun in a circle. But if the sizes of the sun in the pictures are different from each other, the orbit of the

revolution of the earth is not a circle. This method, used to determine if or not the orbit of the earth is a circle, is so simple that even an elementary school student can come up with it. Such a simple method, however, can lead to a remarkably important truth of astronomy---in what kind of orbit is the earth going around the sun. A simple concept may be used to learn a one step higher truth.

What if the orbit of the moon moving around the earth? The picture below on the left is one about a half moon and on the right about a full moon. Which looks bigger? The half moon does. It means that a half moon approaches more the earth than a full moon. At this point, let's remind us of the knowledge acquired at our elementary school days. A full moon appears when the sun stands at a 180 degrees angle with the earth and the moon. In contrast, a half moon comes when the sun stands at a 90 degrees angle with the earth and the moon. The size of the moons shows at which angle the sun stands with the earth and the moon. The size of the moon shows the distance between the moon and the earth. Then, what can we determine, seeing the change in the sizes and phases of the moon? It enables us to guess the orbit of the moon. A scientific concept at the level of a middle school student will contribute to the finding-out of another professional knowledge of science.

3. Science gifted children develop scientific creativity

Repetition of such thinking and researching processes after starting from small and easy concepts will lead to creative, challenging, and competitive thinking. In this process, students come to learn how to cooperate and reconcile with each other, take responsibility for each other, and finally to be trusted by each other. I think it should be repeatedly stressed that being equipped with various abilities through the process of doing science shall lead to Servant Leadership including 7C's and accomplishment of the purposes of the gifted education we are now promoting.