

## Key Competencies Needed for Future in the Republic of Korea - Problem Solving Ability : Ability to Integrate -

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### Introduction

What kinds of competencies we have to bring up in education for the future is very fundamental and important question we have to ask. That is because such ideas have to be considered as a base for the construction of curriculum and assessment in any countries.

Problem solving is the most important capability needed for future society for Korea and bring up problem solving ability(Ministry of Education, 1997) and measurement of such capability is major focus in national test of Korea(Kim Joohoon et al., 2005; Kim Jaechul et al., 2006; Civil Service Commission,2007). Organization of Economic Cooperation & Development (OECD) Programme for International Student Assessment(PISA) also assessed the problem solving ability as a major domain as a goal of education (PISA,2004). So I would like to describe why problem solving is so important and how such capability is measured in the national level test in Korea.

### 1. What is Problem Solving

Problem solving is the complex and high order of ability and fundamental capability (Goldstein & Levin,1987; Mayer,1992; Newell & Simon,1972) that have to be pursued and evaluated in education in any academic subjects(Sternberg & Frensch,1991;

Kay,1991). Also there are common processes of problem solving such as problem finding, hypothesis and plan for problem solving, experiment /carrying out problem solving, results and evaluation (Project2061, 1989; Wellington, 1989).

Problem solving is very broad concept and there are various level of problem solving ability such as problem solving in daily life to problem solving for new era that has changed the human culture revolutionary (Uchida D. et al.,1996).

The basic mechanism of problem solving is integration of different facts, concepts and principles so the essence of problem solving is integration (Fogarty, 1991; UNESCO, 1986). So in this paper, the importance of integration in problem solving will be shown.

### 2. Example of Problem Solving: Integration of Different Concepts

I would like to introduce several examples of problem solving, and problem solving is process of integration. Without the integration of related concepts, there is no meaningful problem solving, namely learning.

#### 2.1. Comparison of Price of Pizza

You have experience enjoy pizza in pizza store. In a pizza store, the price of radius

30cm pizza is 3\$ and 40cm pizza is 4\$. If you have such information how can you make use of the situation for the activation of student's interests and concern for learning?<sup>1</sup> If you ask only one question make use of this example in your classroom for the students, what question are you going to ask? Maybe a lot of questions are possible. But 'which pizza is cheaper?' is very meaningful question at the formative assessment of mathematics classroom after lesson of calculation of the area of circle. Even though students learn how to calculate the area of circle, it is not easy to the learned principle apply to this situation, namely to calculate the area of pizza. If students have experience to apply the learned concepts and principles to real life situation, they can recognize the usefulness and importance of learning and absorbed more for the classroom learning afterwards. It is not easy for students to connect or integrate the experience of calculation of area of circle to the comparison of price of pizza.

If we don't provide this kind of integrative learning experience in the classroom activity, students never connect or integrate the experience of calculation of area of circle with the price of pizza in unit area throughout their life. The area of circle and the size of pizza are different concepts, but linking, in other word, integration of the different concepts and recognition of the common denominator is the key for this example.

2.2. Comparison of Price of Watermelon.  
But the comparison of price of pizza is

not enough experience even though it is very excellent idea. So more learning experiences have to be added to extend integration of the related concepts of this lesson. If the price of watermelon is 3\$ for the radius 30cm and 4\$ for 40cm, which watermelon is cheaper? Is this question connected to the price of pizza? The area of pizza is  $\pi r^2$ , and the volume of watermelon is  $\frac{4}{3} \pi r^3$ . So if the ratio of price is maintained same, the price of unit volume of watermelon is cheaper than unit area of pizza because the volume is proportional  $r^3$  and area of pizza is proportional to  $r^2$ . Even though the situations of problems are different in pizza and watermelon, the two problems can be integrated common factor, namely radius. So if you buy bigger watermelon in radius, the gain is much bigger in contrast to the increase of radius. If you are housewife you can have a lot of such chances when you enjoy shopping.

### 2.3. Extension of Watermelon Problem

If we extend the pizza and watermelon problem to other cases such as melon, fish and lobster, can we apply same principles to those cases? In case of you buy melon, even if it is not round like watermelon, you make round like watermelon by cutting the outside edge of melon. Then you can apply same principle to the melon. It is same for fish and lobster. The shape of fish and lobster is not round but the same laws and principles can be applied. So it is very good question if you deal with such goods how would you transact such goods. So if you transact expensive goods such as sushi fish or lobster you shouldn't deal with such goods as size but weight.

<sup>1</sup> This idea was adopted from the test item of PISA2003.

#### 2.4. Establish Pizza Store

The series of learning experiences until now is very excellent. But we extend the pizza problems not only confined to mathematics problem but also to complex real world problems many variables are included such as establish pizza store. You want to establish pizza store invest all your money and simulate what kind of conditions such as location of store, strategies for cost, marketing etc. should be met if you succeeded in your business. By this activity students can recognize the complexity of human affairs and extend viewpoints experienced in the problem solving to the real world situation that is really valuable and important educational goals.

### 3. Change of Intellectual Structure in the Problem Solving Process

In the process of problem solving in pizza there is change in the intellectual structure. Pizza problem is the comparison of price of unit area from the size(radius) and price of pizza. Watermelon problem is the comparison of price of unit volume from the size(radius). Watermelon problem needs deeper thinking ability to compare the pizza problem. Melon, fish and lobster problem needs of extension of thinking ability over the watermelon problem and most complicated problem. Establishing pizza store problem is extension of the pizza problem to humane and real life situation.

If students carry out those activities separately without interconnection of each activity, the feeling and the achievement of students are totally different from current integrated activity. The core of those activities is the relatedness and integration of series of

unit activity. This is why we want to avoid the lessen of fragmented knowledge. It is meaningless with separated unit lessen even though the lessen itself is excellent one.

In oriental proverb, genius is who listen one word can imagine ten things. If students experience like those integrated lessen, in case of he/she hear pizza he/she can think about radius, area, watermelon, volume, melon, fish, lobster, pizza store, all the related concepts, principles and phenomena. A person who think about only pizza when he/she hear pizza and a person who think about a lot of related concepts and phenomena, there is big difference in the problem solving ability and creativity.

Creativity is determined when a person confront problem, how many ideas he/she can think about related to the problem situation. So to bring up creativity it is essential to experience in the integrated learning rather than dependent separate learning. So learning in the integrative problem solving is indispensable for bring up creativity (Forgaty,1991; Sternberg,1995).

In case of learning by integrative experiences, strong intellectual structure and strong value system are constructed (Sternberg, 1995). For example students experience a series of problem solving from area of pizza to establish pizza store, they can recognize the value and importance of mathematics in daily life, love and enthusiasm for mathematics.

### 4.Integration and Intellectual /Conceptual Development

Also concept and intellectual development

is the process of integration of different concepts and phenomena, namely organization (Piaget, 1972). Let me introduce an example of conceptual development. If you are given such words as pine, rose and ginkgo, what is your idea? You will think 'plant'. If you are given such words as butterfly, puppy and rabbit, what is your idea? You will think 'animal'. This is a process of higher level of concept development and also process of integration. If the words like pine, rose and ginkgo are proposed to you, you analyze the characteristics of the given concepts and draw the common and different characteristics. But our mind does not leave the concepts in the separated state but integrate to higher level concept, such as 'plant'. This is general process of conceptual development. Also plant and animal are integrated higher-level concept 'living things'. So the conceptual development process is process of conceptual integration and it is natural process of human intellectual development, namely organization (Parker & McKinney, 1999). Classification is opposite direction of integration. But the mechanism of classification is same as the integration. If somebody cannot classify he may not be able to integrate.

In the intellectual development stage, children ask a lot of questions in the age of preoperational stage (age of 3 to 4) and quit asking questions in the early concrete operational stage (age of 5 to 6). This phenomenon also can be explained integration (Parker & McKinney, 1999). When preoperational stage children have a lot of experiences but they can't integrate so many experiences to higher level of concepts, laws and principles. Their experiences are separated and

can't have chance to integrate higher level that produce naturally many questions. When children continue development to concrete operational stage they form higher level of concepts, laws and principles that can integrate respective children's experiences that reduce drastically the number of questions of children. So it is good evidence that children are developing normally when raise a lot of questions in preoperational stage and stop questioning in concrete operational stage.

### 5. Various Examples of Integration

There are a lot of examples of integration that provided problem solving. Also there are historically important examples of integration that dedicated to the development of human history.

First of all, recent invention of new machine is good example of integration. Not only the intellectual development but also machines are developed by integration. For example cellular phone is not only telephone but also camera, radio, MP3, television, computer, home automation controller etc. Before telephone has only one function for communication, but nowadays integration of various networking function that carry out a lot of complicated functions. Because telephone is a portal site that make communicate a person to outside world, so children who are accustomed to cellular phone can't stand one moment without the machine. Printer also has not only printing function but also copying, fax function by integration of diverse function.

Computer can't compete human beings

even though computer store a lot of information that human can't have. It is because computer store information in directory as latent form that cannot be activated without the help of software. Without the command of human beings by software, the computer itself can do nothing. If we develop software that automatically integrate the directory of computer and integrate the information, computer will compete human beings in the future. The essence is the difference of ability to integrate information. The amount of information of respective person can't comparable in contrast to computer, but human being has ability to create new information by integration of information and knowledge that he/she has. This is fundamental difference from computer to human beings.

In historical point of view, quantum theory is revolutionary theory from the Newtonian world. The concept of time, space and material is totally different. In such point of view, quantum theory gives us new perspectives and values for the world we live. The unified field theory is the integration of the two theories and will give us new perspectives for the world we live.

For nature, there are male and female in living things and positive and negative for material world. The integration of male and female produce out springs that endure the species of parents, and integration of positive and negative produce new phenomena that are different from the original. In human society, everybody has different views, needs and goals, so need leadership that integrate the individual differences and give each person visions and perspectives.

## **6. Factors Affecting Problem Solving**

Factors such as knowledge, thinking ability and affective characteristics influence the problem solving ability (Sternberg, 1995). Person who has deep knowledge, passion for the problems, high thinking ability will have high problem solving ability, but integration of three factors is also important for the problem solving (Williams, 1970; Betts, 1991). So providing proper knowledge, raising thinking ability and affective characteristics are important objectives of education. This kind of learning can be possible in the integrative learning experiences.

If someone has strong interests and concern for the specified problem, there is possibility he/she can solve the problem efficiently and satisfactorily. Also someone has profound knowledge background and behavioral characteristics such as thinking ability, psychomotor skills etc., he/she can have better chance to solve the problems effectively in contrast to others.

I would like to specially remark for the psychomotor skills. For orient the manual skill using hands and fingers are developed very much. The reasons for that are the oriental cultural background such as using chopsticks, needles etc. in daily life. Recent industry such as semiconductor, micro-techniques in biotechnology, nano-technology needs very fine manual skills. If the education system can't bring up the needed manual skills that can support the development of such industry, the society suffer very much and behind such fields of industry. The reason semiconductor industry is developed only in orient is one example.

## **7. Personal Differences of Problem**

### **Solving: Aptitude**

As Gardner(1983) indicated, there is difference in the personal aptitude. Aptitude is the reflection of personal difference of problem solving ability. Someone has aptitude for arts and someone for mathematics. It is because one's knowledge, thinking ability and affective characteristics, namely intellectual structure, is different from the other.

Aptitude can be well observed in instructional situation such as student's activity and performance assessment. In test situation, aptitude is not easily observed in respective subject test, but comparison of several test results. If a student has aptitude for mathematics but not language, his/her grade for mathematics will be better in mathematics than language. So test results are good indicator for the determination of his/her aptitude for special subject.

One of the important goals of education is identify the aptitude of students and bring up the aptitude so as to maintain happy life. So we have to include aptitude as important part of education, even in testing situation.

### **8. Measurement of Problem Solving - Ability in the National Test in Korea-**

In Korea, most national level tests measure the comprehensive problem solving ability based on the integrative capability. But there is difference from test to test in detail.

Tests such as College Scholastic Ability Test and Medical/Dental Education Eligibility Test rely on contents areas even though they stress the harmony of

thinking ability(Korea Institute of Curriculum & Evaluation,2007; Kim Jooheon et al.,2005). The Public Service Aptitude Test, which is recently introduced, stresses the thinking ability rather than knowledge(Civil Service Commission,2007). Legal Aptitude Test, according to basic research result, is also thinking ability oriented test(Kim Jooheon et al.,2006).

#### **8.1. College Scholastic Ability Test**

Before 1993, the College Scholastic Ability Test (CSAT) that had developed almost 10 years experimental research and implementation was first introduced, entrance examination test items measured the storage of knowledge and information, namely achievement test. College Scholastic Ability Test is first aptitude style test introduced in Korea even though there are differences from domain to domain. Students who want to apply for college/university have to choose several domains among five domains such as verbal reasoning, mathematical inquiry, social study/science/vocational inquiry, English and second foreign language. Also the balance of achievement and aptitude is changed as the characteristics of College Scholastic Ability Test changed. Especially recent policy of the easy test item stressed the characteristics of achievement test rather than aptitude test.

Highest problem solving ability of Korea in international comparison of OECD PISA in 2003 is influence of the College Scholastic Ability Test that has leded Korean education more than 20 years, I suppose. The basic framework of test item development of the College Scholastic Ability Test in science inquiry

is shown in Table 1. Because other domains in College Scholastic Ability Test behavioral objectives are similar to science inquiry domain even though there are minor differences according to domains, only the framework of science inquiry domain is shown as an example.

Table 1. Basic framework of test item development of the CSAT science inquiry

| Behavioral objective | Problem understanding & recognition | Inquiry designing & performing | Data analysis & interpretation | Conclusion & evaluation |
|----------------------|-------------------------------------|--------------------------------|--------------------------------|-------------------------|
| Physics              |                                     |                                |                                |                         |
| Chemistry            |                                     |                                |                                |                         |
| Biology              |                                     |                                |                                |                         |
| Earth science        |                                     |                                |                                |                         |

### 8.2. Medical/Dental Education Eligibility Test

The medical and dental graduate school were introduced from 2005 in Korea and the applicants to enter the 4 years medical/dental graduate school after 4 years of college/university education have to take Medical/Dental Education Eligibility Test. Korea Institute of Curriculum & Evaluation(KICE) developed Medical/Dental Education Eligibility Test on the base of the medical and dental school eligibility basic plan(Ministry of education & Human Resources,2002), and basic researches. Domains such as verbal reasoning, natural science reasoning I, natural science reasoning II are tested in Medical/Dental Education Eligibility Test (Kim Joocheon et al.,2005; Kim Jaechul et al.,2006)\*2.

The verbal reasoning domain measures the ability of understanding of language, communication ability, and problem

solving ability necessary for the medical and dental graduate school education by using materials in the fields of liberal arts, social studies, science, technology, literature and art. The test item of the verbal reasoning is made so that the applicants who finish college course can solve the problem using given information in the test item without any additional prior information and knowledge. The verbal reasoning ability is measured mainly by reading. Listening, speaking and writing abilities are indirectly measured through reading. The basic frame of evaluation for verbal reasoning ability can be expressed three dimensions such as content, behavior and context (Kim Joocheon et al. 2005) (Figure 1).

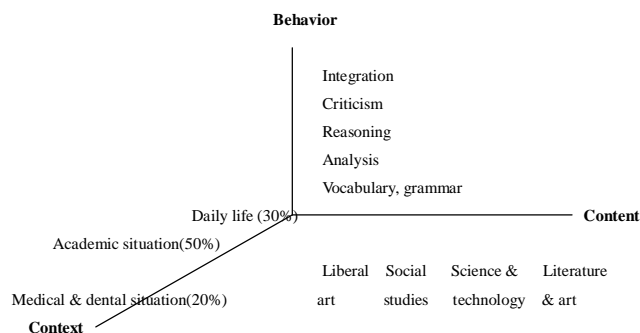


Figure 1. Basic frame of evaluation for verbal reasoning

The natural science reasoning domain measures the scientific reasoning and problem solving ability necessary for the medical and dental graduate school education based on the basic concept and knowledge of general biology. The concept and knowledge used for natural science reasoning I is on the level of general biology. The basic frame of evaluation for natural science reasoning I can be expressed three dimensions such as content, behavior and context (Figure 2).

\*2 Spatial ability test was excluded in 2007 from the Dental Education Eligibility Test.

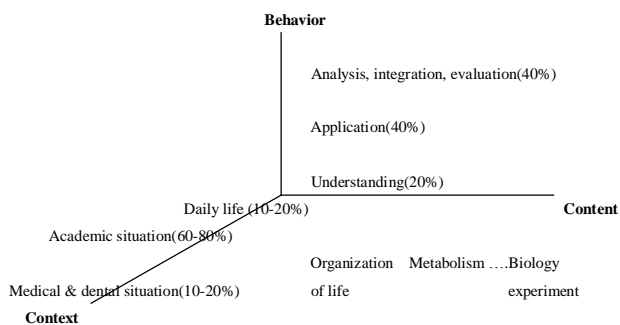


Figure 2. Basic frame of evaluation for natural science reasoning

The natural science reasoning II domain measures the scientific reasoning and problem solving ability necessary for the medical and dental graduate school education based on the basic concept and knowledge of general chemistry, organic chemistry, general physics and general statistics. The other perspectives of natural science reasoning II are similar to natural science reasoning I except the contents of testing.

### 8.3. Public Service Aptitude Test

Public Service Aptitude Test(PSAT) was introduced in Korea for the selection of governmental employee from 2004 after 5 years research and experimental implementation and revolutionary test to substitute the traditional knowledge based test(Civil Service Commission,2007). The basic principles of item development stress the measurement of learning ability and comprehensive problem solving ability including high mental ability avoiding the acquired specified knowledge. In case of specific knowledge is necessary to solve the problem, such information should be provided in the test item.

PSAT has three domains such as linguistic and logical ability test, data interpretation ability test, circumstantial judgment ability test. The contents of evaluation are prescribed in Table 2 (Civil Service Commission, 2007). Anyway, the PSAT reformed the selection system of public servants and test that stress problem solving for the public service of government.

Table 2. Domains and contents of evaluation in PSAT

| Domain                               | Contents of evaluation   |
|--------------------------------------|--|
| Linguistic and logical ability test  | Basic linguistic competencies such as forming a complete sentence, understanding and being understood by others, logical thinking, expressing their idea clearly and effectively, and reasoning  |
| Data interpretation ability test     | Ability to use basic statistic skills and to interpret the results. Also the ability to adjust and analyze numerical data, the ability to utilize the information technology and the ability to keep up with the most recent information |
| Circumstantial judgment ability test | Deductive reasoning, analysis competency, problem solving ability, judgment and decision making ability  |

### 8.4. Legal Aptitude Test

Basic research was carried out for Legal Aptitude Test in 2006(Kim Jooheon et al, 2006) even though legislation for law school was not done. It is expected Legal Aptitude Test will be effective as soon as the law for law school passed the National Parliament.

In Legal Aptitude Test, two domains such as verbal reasoning, reasoning and argumentation will be tested. In contrast to College Scholastic Ability Test and Medical/Dental Education Eligibility Test, Legal Aptitude Test is more problem solving ability test oriented assessment(Kim Jooheon et al, 2006). The framework of item development of verbal reasoning and reasoning & argumentation are shown in Table 3, 4.

Table 3. Framework of item development of verbal reasoning in Legal Aptitude Test

| Cognitive            | Analytical understanding | Inferential understanding | Critical understanding | Creative understanding |
|----------------------|--------------------------|---------------------------|------------------------|------------------------|
| Humanity             |                          |                           |                        |                        |
| Social science       |                          |                           |                        |                        |
| Science & technology |                          |                           |                        |                        |
| Arts & literature    |                          |                           |                        |                        |

Table 4. Framework of item development of reasoning & argumentation in Legal Aptitude Test

| Cognitive Contents   |                      | Reasoning         |                        |                | Argumentation          |                            |                       | Cognitive Contents             |                           |
|----------------------|----------------------|-------------------|------------------------|----------------|------------------------|----------------------------|-----------------------|--------------------------------|---------------------------|
| Science of reasoning | Logics               | Logical reasoning | Mathematical reasoning | Logical puzzle | Analytical recognition | Refutation & argumentation | Judgment & evaluation |                                |                           |
|                      | Mathematics          |                   |                        |                |                        |                            |                       |                                |                           |
| Science of contents  | Humanities           |                   |                        |                |                        |                            |                       | Humanities                     | Theoretical argumentation |
|                      | Social science       |                   |                        |                |                        |                            |                       | Social science                 |                           |
|                      | Science & technology |                   |                        |                |                        |                            |                       | Science & technology           |                           |
|                      |                      |                   |                        |                |                        |                            |                       | Ordinary & moral argumentation | Practical argumentation   |
|                      |                      |                   |                        |                |                        |                            |                       | Policy & decision making       |                           |
|                      |                      |                   |                        |                |                        |                            |                       | Legal argumentation            |                           |

**Summary**

Problem solving ability is the key competency that has to be brought up for Korean education for the future. So problem solving ability is focal ability stressed in national curriculum and national level test such as College Scholastic Ability Test, Medical/Dental Education Eligibility Test, Legal Aptitude Test and Public Service Aptitude Test.

The basic mechanism of problem solving ability is the ability to integrate

different facts, concepts and principles. The human intellectual development processes, historical development of new concepts, development of new products are process of integration. Factors such as knowledge, thinking ability and affective characteristics affect the capability of problem solving. Personal difference of aptitude is also the result of prolonged difference of problem solving ability that is capability of integration.

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## 【機関紹介】

**Korean Institute of Curriculum & Education (略称 KICE)****概要**

KICE は、1998 年 1 月 1 日に KICE 法に基づき発足した、政府資金で運営される研究機関である。その研究成果には定評がある。ナショナルカリキュラムや教育評価だけでなく、教師の指導テクニック向上、教科書開発や認定、全国学力テストの開発も行っている。韓国の主要な教育シンクタンクをめざし、知見を蓄えている。

スタッフの人数は、80 人の研究者を含み、合計 140 人。オフィスはソウルの中心地に位置する。政府、大学、教師、生徒とセミナーなどを通して密接に連携している。

**主な研究領域**

主に初等・中等教育カリキュラムに関する研究を行っている。国際調査結果も研究しながら、国の学習指導要領に提言を行う。主な研究領域と実行項目は次の 6 つである。1) カリキュラムの研究開発(ナショナルカリキュラムの開発、カリキュラム国際比較など)、2) 教科書開発と認定(政府発行の教科書の開発、出版者発行の教科書の認定、研究など)、3) 教育の評価(全国レベルの到達テストの開発と実施、国際学力調査への参加など)、4) 初等・中等教育の指導メソッド開発(指導テクニック、教材、初等・中等教育学校のための評価の枠組みの開発など)、5) 大学入学資質能力試験 CSAT (College Scholastic Ability Test) の開発、6) 学力テスト開発である。

**開発された教育テスト**

KICE が開発するテストには次のようなものがある。CSAT(College Scholastic Ability Test、大学修学能力試験)、MEET(Medical Education Eligibility Test、医学適性検査)、DEET(Dental Education Eligibility Test、歯学適性検査)、初等教育学校教師選抜検査(Primary School Teacher Selection Test)、中等教育学校教師選抜検査(Secondary School Teacher Selection Test)、TOPIK(Test of Proficiency in Korean、韓国語テスト)、独学で学ぶ学生向け高校入試・高校卒業資格試験(High School Entrance and Graduation Certificate Exam for Self-study Students)、高校入試(High School Entrance Exam)、海外留学生向けの奨学金授与認定テスト(Scholarship Award Test for Students Studying Abroad)、科学研究者のための国家試験(National Test for Special Researchers in Science)、教育人的資源部(日本の文部科学省に相当)と人事院における専門職認定国家試験(National Test for Ministry of Education and Human Resources Development Officers in Special Career Tracks and Supervisors)。

(出典：<http://www.kice.re.kr/kice/eng/index.jsp>)