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Portfolio Assessment as a Policy for Innovating Mathematics Classrooms

KIM, SOO HWAN
Department of Mathematics Education, Chongju National University of Education,
135 Sugok-dong, Heungdeok-gu, Cheongju, Chungbuk 361-712, Korea;
Email: soohwan@cje.ac.kr

For the balanced realization of these values of mathematical culture, we need to innovate mathematics classrooms, for which we need to make use of portfolio assessment.
First, portfolio assessment can be regarded as a method of synthesizing a variety of resources for systematic evaluation.
Second, portfolio assessment can be used as a tool of building up learners' positive attitude toward mathematics, by which we can identify the latent possibility of learners' development and help them develop confidence in mathematics.
Third, portfolio assessment can play an important role as a tool for exploring the method of teaching and learning in which learners recognize the value of mathematics and are interested in mathematical activities, as we have seen in the report on the Gulliver's Travels Project.

I. INTRODUCTION

The social constructivist view of mathematics places subjective knowledge and objective knowledge in mutually supportive and dependent positions. Subjective knowledge leads to the creation of mathematical knowledge, via the medium of social interaction and acceptance. It also sustains and re-creates objective knowledge, which rests on the subjective knowledge of individuals. Representations of objective knowledge are what allow the genesis and re-creation of subjective knowledge.

So we have a creative cycle, with subjective knowledge creating objective knowledge, which in turn leads to the creation of subjective knowledge. <Figure 1> shows the links between the private realm of subjective knowledge and the social realm of objective knowledge, each sustaining the creation of the other. Each must be explicitly represented for this purpose. Thereupon there is an interactive social negotiation process leading to the reformulation of the knowledge and its incorporation into the other realm as new knowledge (Ernest 1991; Kim 1996).

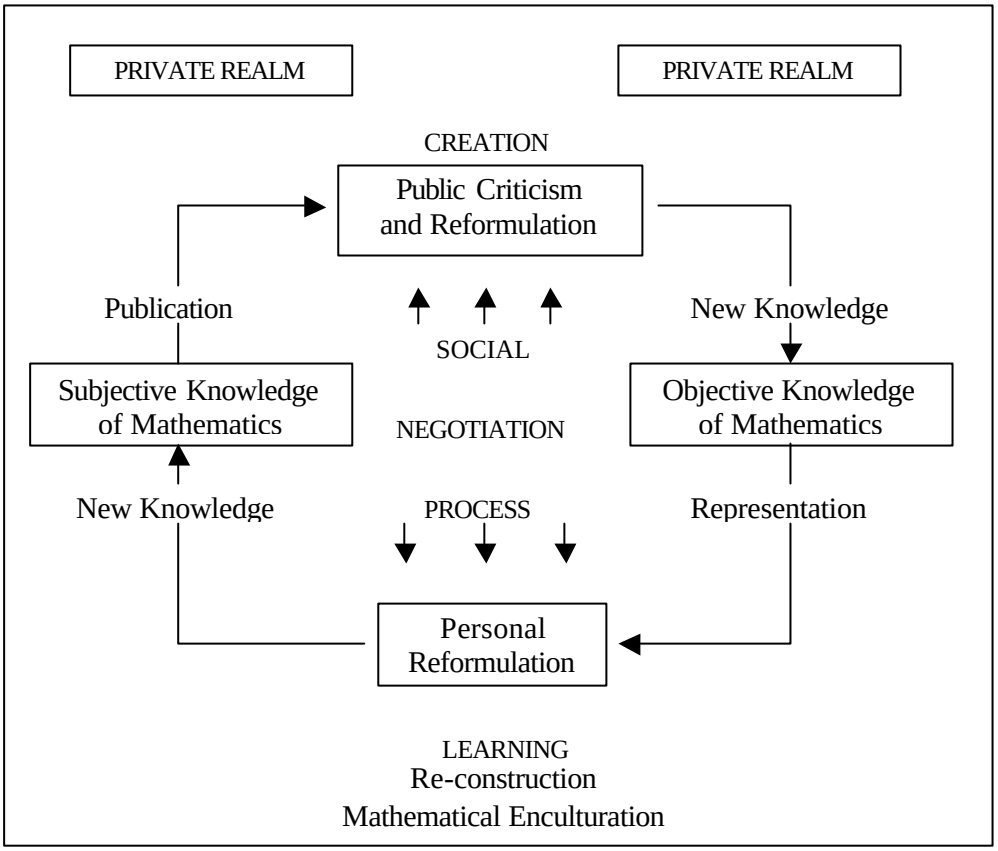

Figure 1. Relationship between the objective and the subjective Knowledge of Mathematics

Even though there are a lot of places for originating social negotiation, the most important place may be the classroom. In other words, mathematics classrooms should be the places of producing social-cultural-cognitive-affective negotiations among learners and teachers. It is not easy for a teacher to pay close attention to each student in a large class. Therefore it is important to find ways for students to do interactive negotiation. We should search for a scheme for this.

Although Korean students performed very well on mathematics and science tests, according to TIMSS News (http://wwwcsteep.bc.edu/TIMSS1/Press.html), there is a severe problem in mathematics education and evaluation in Korea. The problem is that

> mathematics education and evaluation are dominated by the college entrance examination system.

The system has given rise to several social problems, despite our continuous efforts to overcome those problems.

As a part of such efforts, the ranking by relative evaluation disappeared in the elementary school report card. We should make efforts to find and promote learners' latent possibilities for self-realization by means of mathematics evaluation. That is, we should keep in mind the fact that everybody counts.

This study aims at seeking a policy for innovating mathematics classrooms.

- First, the processes of change and problems in the college entrance examination system are investigated.
- Second, the efforts of Korean researches to improve evaluation in mathematics education are reviewed.
- Third, a case for portfolio assessment as a policy for innovating mathematics classrooms is presented.

II. College Entrance Examination in Korea

Any reform of college entrance examination system should be ultimately dependent on its functions and principles.

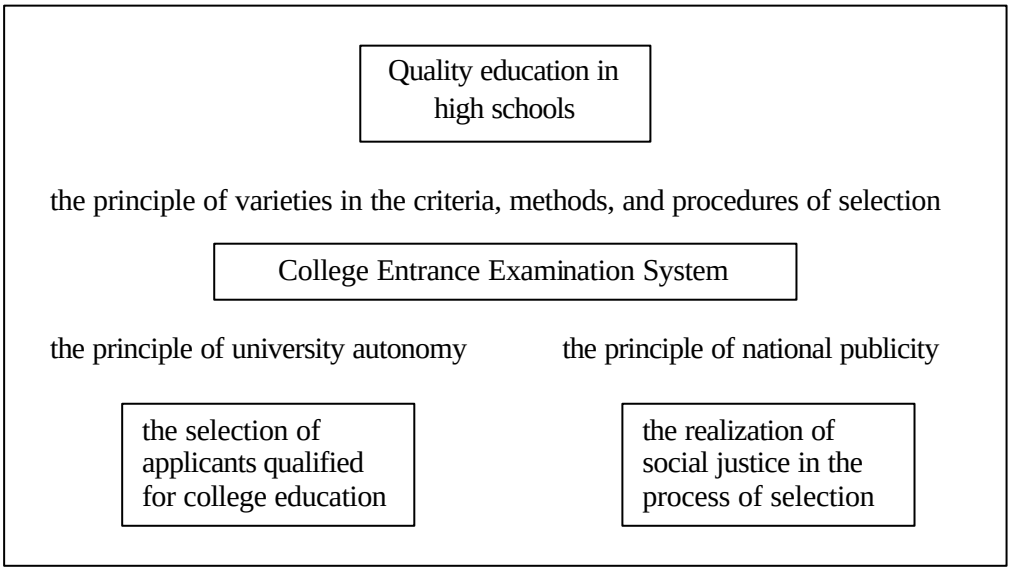

Figure 2. Functions and Principles of College Entrance Examination System

The college entrance examination system in Korea has such functions as quality education in high schools, the selection of applicants qualified for college education, and the realization of social justice in the process of selection. Such principles as the varieties

in the criteria, methods, and procedures of selection for quality education in high schools, the university autonomy in the selection of applicants qualified for college education, and the national publicity for the realization of social justice in the process of selection should be in harmony (KEDI 1992a).

The college entrance examination system in Korea has been changed more than ten times since 1945 (Kim 1993). The problems resulting from the frequent changes can be sum- marized as follows.

First, in the period of making use of the university-run test for selection to maximize the university autonomy, there was a big difference in the standard of entrance examination and the students' scholastic abilities among universities. The result was abnormal education in Korean high schools. Therefore, the principle of university autonomy was strengthened, but the principles of the varieties and the national publicity was weakened.

Second, in the period of making use of the national scholastic achievement test and the high school records, the problems of limited university autonomy and discredit upon the high school records were brought up.

Third, in the period of making use of the national scholastic achievement test and the university-run test, going through two examinations was a burden on students. As well, such social problems as the loss of teachers' privileges owing to the education dominated by college entrance examination and the accumulation of repeaters who is taking the entrance examination after one or two failures were brought up. All these changes led to the conclusion that high school records should be dependable to allow the college entrance examination system to perform its own valuable function.

In fact, we have made continuous efforts to improve the college entrance examination system according to these functions and principles. None the less, the problem of

education and evaluation dominated by college entrance examination

has always been pointed out. In this respect, it is almost impossible for us to expect a perfect system to solve the problem, and people's way of thinking and attitude toward the problem should be changed. The most important thing is to make an improvement in the teacher's usual practice of evaluation. To make the high school records reliable, we should make use of various resources of evaluation in mathematics classrooms.

III. STUDIES ON EVALUATION IN MATHEMATICS EDUCATION

Korean Educational Development Institute (KEDI) has performed such evaluation studies as:

- A Study on New Evaluation System for Quality Mathematics Education (1990–

1992),

- National Curriculum Specifications and Performance Standards for Mathematics in Korean Middle School (1995), and
- A Study on the Teaching/Learning Methods and Evaluation Techniques for Helping Creative Problem-Solving in Mathematics (1997).

In the first year, KEDI (1990) explored the roles of and recommendations for evaluation in mathematics education to seek for quality education. Accordingly, major problems in current evaluation practices in mathematics education were identified, and possible measures to improve the problem were suggested in the following aspects: evaluation of problem-solving ability, evaluation of mathematical aptitude, specification of education objectives, composition and administration of scientific evaluation items, and utilization of evaluation results.

In the second year, KEDI (1991) analyzed evaluation practices in mathematics education in elementary and secondary schools, and developed tentative evaluation systems and tools. Theoretical explorations of evaluation models were analyzed. A new evaluation system was developed on the basis of the overall evaluation system for quality education which had been developed in the previous year. A tentative evaluation tool for one unit of each of 5th, 8th, and 11th grades was developed on grounds of this system.

In the study of the concluding year, KEDI (1992b) developed evaluation tools on the basis of research results of the first two years. As for cognitive evaluation tools, softwares for diagnostic and formative evaluations, and a pencil-and-paper test for overall assessment were developed. As for affective evaluation tools, tests to analyze/observe mathematical aptitude and learning attitude and a checklist for such aptitudes were developed.

In KEDI (1995), educational objective specifications for *Mathematics* in middle school were described as two tables (content $\times$ behavior). The content area was divided into sub-areas following the National Curriculum for Mathematics. The behavior area consisted of knowledge, skill, problem-solving areas, and attitude. In addition, each sub-content area included appropriate teaching skills and valid evaluation methods. Finally, three levels of performance standards for each sub-content area were described for providing objective and valid information about each student's achievement level, no matter where he/she lived or studied.

In KEDI (1997), to innovate mathematics classrooms, such evaluation techniques as analytic scoring for the subjective questions, portfolio assessment, assessment for project activities, and a checklist for observing and interviewing were suggested. The Seoul Office of Education has been trying to supply these evaluation techniques for in-service teachers.

IV. PORTFOLIO ASSESSMENT IN MATHEMATICS CLASSROOMS

1. Portfolio Assessment

According to *Webster's Third New International Dictionary*, a "portfolio" is defined as

1) a flat portable case (as a briefcase, a large heavy envelope, or a loose-leaf binder) for carrying papers or drawings,
2) the office and functions of a minister of state or member of a cabinet,
3) the securities held by an investor or the commercial paper held by a bank or other financial house.

Portfolio means a diversified investment of stocks in the field of financial management, and it is for diversification of risks. From a point of educational assessment, it can be considered as an alternative assessment tool to overcome the limitation of product-oriented evaluation, to integrate process and product of learning, and to value and improve learners' personalities.

Portfolio can be defined by students' folders containing the records of their reflective self-evaluation, teachers' comments about examples of their work, problem-solving activities, performing mathematical projects. By portfolio assessment, students can make sense of the process of their intellectual growth, strengths and weaknesses, sincerity, and latent possibility of development. And teachers can not only grasp the cognitive situation of what the learner was and what he is, but also suggest professional advice for his cognitive development. The portfolio assessment can be used to evaluate the level of student's latent development, by identifying Vygotsky's "the proximal zone of development" (Mellin-Olsen 1991; Vygotsky 1978).

Teachers' goals for using students' portfolios are as follows (Lambdin & Walker 1994). First, teachers can look for a better way to assess the whole child rather than just relying on test scores. Second, they can help students develop better self-assessment skills and become less reliant on the grades they assign to students' work. Third, they can establish a better means of communication among students, parents, and teachers about the kinds of mathematical learning taking place in mathematics classrooms.

2. The Criteria for Portfolio Assessment

We anticipate the development of learners' problem-solving and communication skills by means of the portfolio in which they can publish their subjective knowledge of mathematics and represent the objective knowledge of mathematics. Therefore, the modified criteria from the Vermont Portfolio Program (Petit 1992; http//plainfield.bypass.com/bypass/users/union/skills.html 1997) on problem-solving and communication skills

can be used for helping the teachers' comments in the process of a portfolio assessment.

Table 1. Problem-Solving and Communication Skills

Skill \ Level	1	2	3	4
Problem Solving Skill 1 (PS1) Understanding the Problem	PS11	PS12	PS13	PS14
Problem Solving Skill 2 (PS2) How the Student Solved the Problem	PS21	PS22	PS23	PS24
Problem Solving Skill 3 (PS3) So What-Outcomes of Activities	PS31	PS32	PS33	PS34
Communication Skill 1 (C1) Mathematical Representation (Math sentences with charts, graphs, tables, diagrams, models, · · ·)	C11	C12	C13	C14
Communication Skill 2 (C2) Presentation (Organization of the task)	C21	C22	C23	C24

PS11: Misunderstood the problem or did not understand enough to get started or make progress.
PS12: Understood enough to solve a part of the problem or reach a partial solution.
PS13: Understood the problem, including identifying and using any information minimally required to solve the problem.
PS14: Identified special factors beyond those minimally required to solve the problem and applied the factors consistently and correctly.
PS21: Problem-solving approach did not work or no approach was evident.
PS22: Problem-solving approach would lead to solving only a part of the problem or reaching a partial solution.
PS23: Problem-solving approach worked or would work for the problem.
PS24: Problem-solving approach worked and was efficient or sophisticated.
PS31: Solved the problem and stopped or made an observation that was inappropriate or irrelevant.
PS32: Solved the problem and made a mathematically relevant comment or observation about some aspect of his/her solution.
PS33: Solved the problem and made a mathematical connection between the solution and other mathematics or the "real world".
PS34: Solved the problem and made a general rule about the solution or extended the

solution to a more complicated situation.

C11: Used inappropriate mathematical representation or did not use any mathematical representation to communicate the solution.

C12: Attempted to use an appropriate mathematical representation to communicate the solution.

C13: Used an appropriate mathematical representation accurately to communicate the solution.

C14: Used a sophisticated mathematical representation accurately to communicate the solution.

C21: The presentation of the solution was unclear.

C22: The presentation of the solution contained some clear parts.

C23: The presentation of the solution was clear but a reader must fill in some details to understand the solution.

C24: The presentation of the solution was clear throughout, well organized and detailed.

3. The Case of Portfolio Assessment in the Project Activity

According to Webster's New World Dictionary, a "project" is defined as

a proposal of something to be done, a scheme.

In mathematics education, a project may assume a much broader meaning, one that includes not only deciding what must be done but also doing, it, presenting the data, and assessing the findings or results. The project should not be completely defined by the teacher; rather, it should be a group effort with the teacher acting as a guide (Krulik & Rudnick 1995).

Project teaching is a very important mode of teaching, as witnessed by its use in all higher degree work, and reported in dissertations, theses, books, and papers of all kinds. There is, in a sense, nothing really new about using project-work in education, associated as it was with the ideas of John Dewey in the 1920s in America. But for some reason projects do not seem to be used in any extensive way in present-day mathematics education (Bishop 1988).

Projects offer an excellent opportunity for students to become involved in cooperative learning, since projects are generally assigned to groups of students. This helps students sharpen their communications as they talk with other members of their own group and communicate their findings and results to the entire class in both oral and written form. Working together on cooperative projects also helps students develop the ability to work with others, a necessary life skill. Projects also furnish opportunities for creative individual thinking as well as for group discussion and thought (Krulik & Rudnick 1995).

The following is an example of the project activity.

<Project> Gulliver's Travels*:*

For example, an average ninth-grade student in Lilliput is 18cm tall; in Brobdingnag, an average ninth grader is 540 cm tall. Describe your classroom including a student's desk, a teacher's desk, a textbook, a notebook, a pencil, and so on as if it were in Lilliput or in Brobdingnag.

(Teacher's Notes) National statistics show that the average height of a ninth-grade student is about 150cm.

Subjects were forty five 9th graders at a boys' middle school located in Seoul. They were divided into six groups (seven or eight students in each group) and performed the project activities of "*Gulliver's Travels*". The self-assessments, and reflections and impressions written in each group's activity report are as follows:

Table 2. Self-Evaluation in the Project Activity Report (Grade 9)

Eva. / Groups	Students' Reflections and Impressions	Self-Evaluation
1	The sizes of objects in Lilliput and Brobdingnag are realistic. These activities are very useful because the problem solving of measurement by means of the ratio of similarity produces the ratio sense.	Very Good (Level 4)
2	It is novel for us to solve a lot of problems by means of the ratio of similarity. It was not easy to remember the lessons we took when we were 8th graders, but united efforts made it easy.	Good (Level 3)
3	It was interesting for us to measure and calculate objects collaboratively. The work seemed to help us develop the cooperative spirit.	Good (Level 3)
4	To solve the problem, we should know the ratio. At first, we did not know what to do, but collaboration made it easy.	Good (Level 3)
5	It was very extraordinary and interesting. We felt like we were conducting a scientific experiment. I hope to do this kind of activity frequently.	Good (Level 3)
6	I knew that there was a very big difference in size between Lilliput's objects and Brobdingnag's objects.	Good (Level 3)

V. CONCLUSION

We have made continuous efforts to avoid the fact that

the education system dominated by college entrance examinations.

We have been in pursuit of quality education to realize "education for the whole man". In most cases, however, mathematics has played a decisive role as a filter in the entrance examination. It has been regarded as a tool subject for the entrance examination, not as a meaningful subject. A transposition of the way of thinking in mathematics education is required.

In conclusion, students should be provided with mathematics classrooms in which they can recognize mathematical power by doing mathematics as a valuable subject. Bishop (1988) insisted that mathematical culture should have such values as rationalism and objectivism in the ideological dimension, control and progress in the emotional dimension, openness and mystery in the sociological dimension, which should be in harmony with each other. For the balanced realization of these values of mathematical culture, we need to innovate mathematics classrooms, for which we need to make use of portfolio assessment.

First, portfolio assessment can be regarded as a method of synthesizing a variety of resources for systematic evaluation. Mid-term and final examinations, being typical types of overall evaluations centering around the product, have been made use of mainly for grading learners, not for providing feedback to instruction. Of course, it is true that most teachers have made use of not only diagnostic evaluation and formative evaluation but also quizzes and homework to grasp the students' cognitive aspects. But these traditional evaluation methods need to be integrated systematically by portfolio assessment, which is an important tool not only for evaluating problem-solving and communication skills but also for grasping learners' strengths and weaknesses.

Second, portfolio assessment can be used as a tool of building up learners' positive attitude toward mathematics, by which we can identify the latent possibility of learners' development and help them develop confidence in mathematics. It means that we should regard learners' problem-solving abilities as what Vygotsky (1978) calls "the zone of proximal development" which is the distance between the actual developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers. Hence, we should make efforts for teachers to do traditional explanatory instruction, at the same time as we make efforts for students to do collaborative learning and project activities. In fact, society requires collaborative problem-solving in many

cases. Therefore mathematics classrooms should be the place where social negotiation between creation and learning comes into existence.

Third, portfolio assessment can play an important role as a tool for exploring the method of teaching and learning in which learners recognize the value of mathematics and are interested in mathematical activities, as we have seen in the report on the Gulliver's Travels Project.

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