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The Effective Use of Evaluation Results in Mathematics Education

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In order to optimize a learning effect in mathematics, the results of the educational assessment must be effectively used by both teachers and students. The teacher using technology to provide students with performance feedback is becoming more prevalent in educational contexts worldwide but concern arises over the form of that feedback and the effects it has upon students' achievements. Also, feedback takes considerable time for teachers but their instructional time is limited. For these reasons, it is a significant matter how to select items effectively in order to give feedback to students after an assessment. In this study, we introduce the systematic selection method of feedback items using the regression analysis in order to provide effective feedback to students by teachers.

Keywords: evaluation results, teaching and learning design, feedback
ZDM Classification: C73
MSC2000 Classification: 97C90

INTRODUCTION

Black & William (1998) defined assessment broadly to include all activities that teachers and students undertake to get information that can be used diagnostically to alter teaching and learning. Assessment become formative when the information is used to adapt teaching and learning to meet student needs. Formative assessment is an assessment intended to give students feedback on their learning progress and to give the teacher an indication of what students have mastered and their areas of difficulty (Sadler, 1989). Therefore, the results of formative assessment must be effectively used by both teachers and students. William (1996) reported that formative assessment can change the distribution of achievements and good formative assessment has special advantages to lower achiever.

Concepts in mathematics are closely related to each other so that if students do not

completely understand a basic concept, they experience difficulties in solving problems which are related to the basic concept. Therefore, teachers and students should effectively use the formative assessment results in order to perform successively subsequent studies.

The teacher may expect the best instruction effect by making the instruction design based on the assessment results and we call this process feedback in the instruction design. The feedback, the effective use of these assessment results, is the core element of instruction design in mathematics education (Ramaprasad 1983). Also, if students want to know concepts and principles which were not completely understood, they need additional study for the successful performance in the future. In this regard, the assessment results must be provided to student in usable and understandable forms.

Feedback is not only a teachers' way to provide students with information about their responses, but also a critical part of their instructional and assessment strategies (Collis et al. 2001). The teacher using technology to provide students with performance feedback is becoming more prevalent in educational contexts worldwide but concern arises over the form of that feedback and the effects it has upon students' achievements (Bower 2005). Also, feedback takes considerable time for teachers but their instructional time is limited (Collies & Messing 2000). Mathematics teachers have many practical problems in appropriately performing feedback. For these reasons, it is a significant matter how to select items effectively in order to give feedback to students after an assessment.

The purpose of this study is to introduce the systematic selection method of feedback items using the regression analysis under the following assumptions:

(a) In a sufficiently large population, the proportion correct is equivalent to the item difficulty;
(b) Item difficulty level and proportion correct for a small sample have a linear relationship.

Also we assumed that schools have an integrated learning system which processes the assessment results of students, and this system enables both teachers and students to use the assessment results for their decision making.

In Section 2, we reviewed researches about the feedback. Also, we verified the insufficient use of assessment results in South Korea through the reports conducted by the Korean Educational Development Institute and the National Board of Educational Assessment.

In Section 3, we diagnosed that the reason for insufficient use of assessment results is related to a lack of appropriate information about the relationship between the basic item information and the assessment results.

We suggested the systematic selection method of feedback items using the regression analysis in order to provide effective feedback to students by teachers.

THEORY AND PRACTICE OF FEEDBACK

1. Literature Review

The role of feedback as the use of assessment results may be explained in relation with the instruction design. The instruction design is the blueprint showing how and when to use the specific instruction method for the specific content. According to the instruction theory suggested by Gagne (1977) and Briggs (1977), the instruction must be conducted through the processes such as educational goals, prior assessments, class procedures and assessments and also the feedback must be conducted in each process. Dick & Carey (1990) suggested that the process of instruction design consists of developing the assessment items which measure the accomplishment of a designated goal, verifying the difficult part by collecting the assessment results acquired in the process of assessment and complement. Merill (1994) and Reigeluth (1983) considered the instruction design as the method of preparing the educational strategy. Merill (1994) suggested the practice must be conducted in all studying levels and the educational format must differ depending on each studying level. Reigeluth (1983) presented three strategies as the educational method: the organization strategy, the communication strategy and the management strategy. The purpose is to understand, apply and enhance communication methods, such as communication media, instructional methods, interactions, assessments and feedback.

Russell (1994) regarded feedback as the process of comparing a students' performance with a required standard for learning. He argued that the teachers' role is to allow the students to consider the advantages, disadvantages and possible reactions to several alternatives. Wiggings (1998) defined feedback as information about how students performed in the light of what they attempted – intent vs. effect, actual vs. ideal performance.

There is much research that reveals feedback is effective for improving student's achievement. Cassady *et al.* (2001) found significant differences in performance in the final examination between students of 176 first year psychology undergraduates who did and did not take advantage of online formative assessment quizzes. Sonak *et al.* (2002) found a positive relationship between the amounts of time that junior high school students used an online performance feedback system and their academic performance. Yoo and Kang (2003) have examined how to organize develop a web-based diagnostic formative assessment system. They obtained the result that the web-based testing system gets greater studying effectiveness than the paper-pencil test. Byun *et al.* (2004) have explored how to analyze the assessment data by applying knowledge to a computer system and have developed effective methods based on the analyzed results, to diagram each

student's knowledge structure. Using a computer system, they provided students with substantial feedback for the assessment. Also, objective validity was increased along with quick and exact process in a bid to help students' mathematical understanding grow.

However, there is research evidence that every type of feedback is not always effective in every situation. Lewis & Cooney (1986) noted that the feedback conditions were found to differentially affect male and female performance. In their study, females within the individualistic feedback group exhibited a significantly higher rate of progress than females in the competitive feedback group. Becker and Rosen (1992) discounted competency-based grading feedback as a less effective assessment approach to promote academic performance. RIccomini (2002) compared two forms of feedback: Web-based model comparison and indicator delivered corrective feedback. He reported that student's performance was significantly better on the criterion task when they received instructor delivered corrective feedback. Bower (2005) reported online individualistic feedback significantly improves students' performance but competitive feedback had a negative impact on their mathematics ability self-rating.

In this regard, feedback can be a powerful tool to improve student achievement but it should be carefully and thoughtfully designed. We propose that a new information analysis tool for providing feedback is necessary. While competitive feedback is popular in Korea, it can be damaging to a student's self- esteem. On the other hand, individualistic feedback is not realistic given the time constraints on teachers. Hence, a new method is needed to provide the most appropriate feedback given the realities of overburdened teachers. The method we propose is efficient and will reveal the potential weaknesses of the class as a whole to allow the teacher to provide extra practice on identified problems.

2. Feedback Instructions in Korea

Niss (1993) defined assessment as a part of instruction-study on the use of assessment results in mathematics education. Paik (1999) advocated measuring the efficiency of instructional activities by considering the basic intention of assessment as making the diagnosis of each student's mathematics studying activities and enabling each student to understand completely the quality of study by diagnosing the difficulty in studying. In other words, the basic feedback provided regarding each student's study or learning must play an important role in the instruction design and process.

According to the data on the use of assessment results at the educational sites surveyed by the Korean Educational Development Institute (1992), the diagnosis assessments were surveyed to be used for the supplemental study in 92.1% of elementary schools, 83.3% of middle schools and 73.5% of high schools respectively, and the formative assessments were surveyed to be used for the supplemental study in the 92.1% of elementary schools, 83.3% of middle schools and 76.8% of high schools respectively. 60% of teachers said

they observed and recorded the students' mathematics studying activities but do not used systematic method in this process.

The National Board of Educational Assessment (1996) examined how Korean mathematics teachers evaluated their students based on the TIMSS data set. Most middle school mathematics teachers answered that they evaluated their students focused on the students, response in the class (59.1%), short answer or descriptive items (51.6%) and combined items (36.0%). 60.9% of teachers answered that they used the assessment results when they diagnose the learning state of students and only 38.7% of teachers used the assessment results when they provided feedback to their students.

In the research on the actual state of feedback mathematics instruction in the middle school by Won & Nam (2002), only 19.3% of teachers said they had the sufficient data for feedback instructions. We should note that the assessment results were insufficiently used for the supplemental class in the middle and high schools. In terms of the assessment reporting format, those reports showed that assessment results were provided to each student in an unusable form.

FEEDBACK ITEM SELECTION METHOD USING REGRESSION

First of all, the teacher should be able to check appropriately whether every student completely understood each concept or principle of the assessment areas in order to provide feedback using the assessment results. In this regard, teachers must specify which concepts or principles are related with each item and which abilities are required for solving the item. Developing the assessment tools, teachers should know the basic information of each item which constitutes relevant theories, required abilities such as computation, understanding, reasoning, and the characteristic parameters such as difficulty level or discrimination, in order to check the student's state of understanding by analyzing the response against the item.

Now we consider if it is available for teachers to provide the correct feedback to each student using the assessment results under the assumption of correctly providing the basic item information. However, it is not easy for teachers to provide effective feedback to each student with only the basic item information. The relation between basic item information and feedback information acquired in the process of assessment is not clearly defined. Therefore, we need an analysis system consisting of constructive algorithms used when deciding the definite contents of feedback by understanding the relation between assessment results and item information.

The primary assessment information acquired from the assessment results is the information whether each student responds correctly to each item. Through this

information, the teacher acquires the correct answer rate. At first glance, the content needed for feedback to students might be considered as the item showing the lowest correct answer rate and relevant concepts or principles. However, if the item shows high level difficulty regardless of relevant contents, or when the contents requires an excessive difficult level exceeding the general studying goal, the teacher engaged in the teaching and learning design within the designated time and resource may not be considered to have made the correct decision in the case of providing the feedback on the contents of these items.

Regression analysis is used to model relationships between random variables and can be used to make predictions based on these models. Simple linear regression refers to a regression on one dependent variable and one independent variable. Since we can assume that the proportion correct of an item for a population can predict the proportions correct of the item for a sample, we apply regression analysis with the proportion correct of the item for the sample as the dependent variable and the proportion correct of an item for a population as the independent variable.

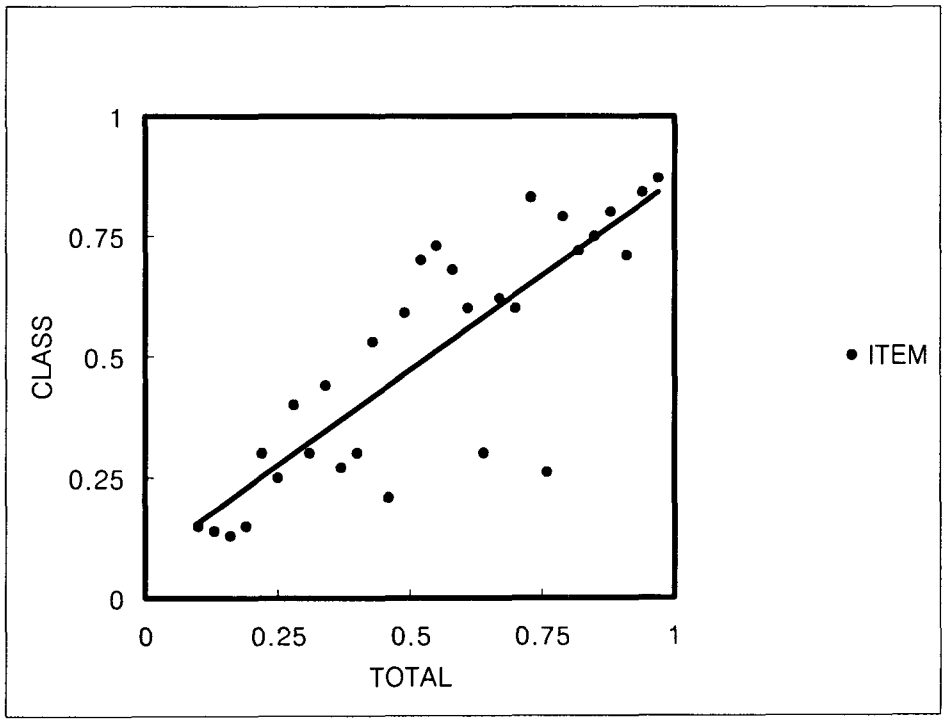

Figure 1. The relation between basic item information and assessment results

Now, we are to exemplify the plan how to effectively use the assessment results by clarifying the relation between basic item information and assessment results. Figure 1 is

the item distribution table made of correct answer rates in imaginary assessment results. The vertical axis y shows the proportion correct in a class and the horizontal axis shows the proportion correct of the sufficiently large amount of students sample (we will called this 'total proportion correct') or the difficulty level of the item in item. Each point on this graph is considered the point representing each item, so the x coordinate of each item point indicates the total proportion correct and the y coordinate indicates the proportion correct of a class. The straight line L is the regression line acquired through the regression analysis of the provided data.

The Teacher must extract the item showing a big residual which is far from the regression line, out of points of which the x coordinate is bigger than the y coordinate as the item requiring the feedback. These items show a greater total proportion correct and a relatively high proportion incorrect in the class. A bigger residual under the regression line means the more possibilities of significant defect in the teaching and learning process on relevant contents of the item. This method gives the teacher an effective algorithm for deciding a priority for feedback contents.

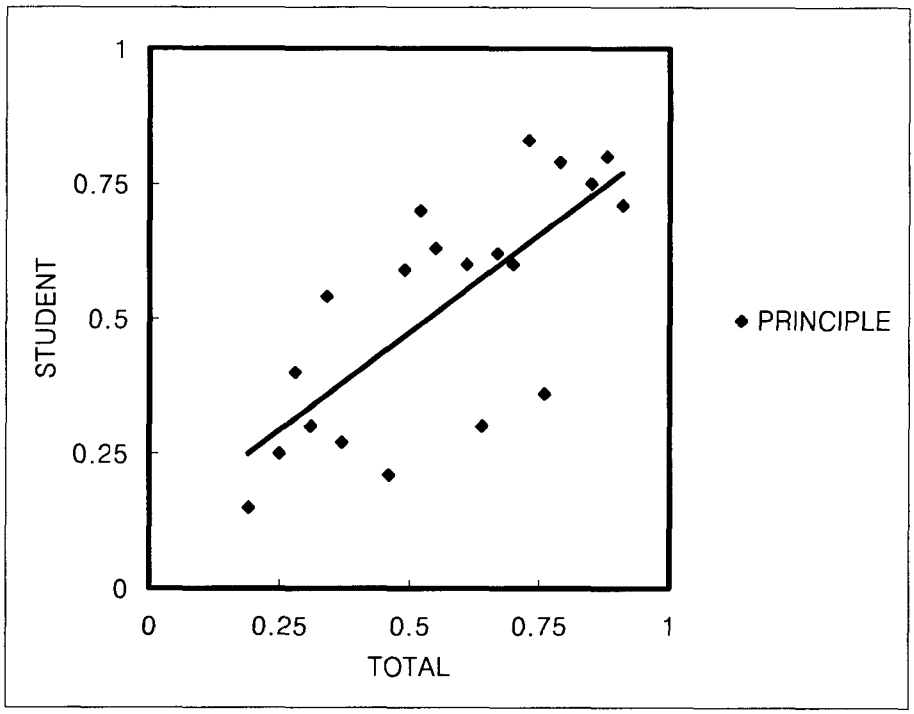

Figure 2. The proportion correct of each principle

If each student does not completely understand the specific concept and principle, he or she must try to understand the concept and principle through additional study using the

assessment results. First, collect the items related to each principle and concept. Second, acquire the proportional number of all such problems to the number of correctly answered problems, define it to be the proportion correct of each principle or concept and place it on the y axis. Third, acquire the average value of the total proportion correct related to the specific principle or concept and then place it on the x axis. Assuming imaginary test results, Figure 2 shows the distribution of points consisting of the individual proportion correct of each principle or concept as y coordinate and the total proportion correct of each principle or concept as x coordinate by each principle or concept.

Each student may extract the principle requiring more study using the distribution of the coordinate. Here, the student must extract the item showing a large residual which falls away from the regression line out of points of which the x coordinate is bigger than y coordinate as the item requiring the feedback. These items showing a high total correct answer rate and a relatively high incorrect answer rate as compared with the student's indicate the items which are poorly understood in the studying process.

CONCLUSIONS

The importance of feedback from the use of assessment results is well established as the core element of modern instruction design theory. Also most Korean teachers or students are well aware of the importance of feedback. However, it is not used sufficiently in terms of quality and quantity because the assessment results are not provided in the form of information which may be used efficiently by either teachers or students. A lot of effort is required for appropriately providing this kind of assessment information.

Intending to use the assessment results effectively, we need a computer-aided assessment system analyzing the requirements for the assessment result information, designing the standardized measuring tools for extracting the required information and providing the teaching and learning model required for the effective use of assessment information. Also, the Integrated Learning System enabling the integration of overall processes in terms of educational technology should provide teachers and students with feed back in a more convenient way. The essential relationship between teacher and student including overall elements forming a part of instruction-study system will be formed appropriately in these processes.

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