

A Study on Performance Assessment Methods by Using Fuzzy Logic

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Abstract

Performance assessment was introduced to improvement of self-directed learning and method of assessment for differentiated learning as the seventh educational curriculum is enforced. Performance assessment is overcoming limitation about problem solving ability and higher thinking abilities assessment that is problem of a written examination and get into the spotlight by way for quality of class and school normalization. But, performance assessment has problems about possibilities of assessment fault by appraisal, fairness, reliability, and validity of grading, ambiguity of grading standard, difficulty about objectivity security etc.

This study proposes fuzzy performance assessment system to solve problem of the conventional performance assessment. This paper presented an objective and reliable performance assessment method through fuzzy reasoning, design fuzzy membership function and define fuzzy rule analyzing factor that influence in each sacred ground of performance assessment to account principle subject. Also, performance assessment item divides by formation estimation and subject estimation and designed membership function in proposed performance assessment method. Performance assessment result that is worked through fuzzy performance assessment system can pare down burden about appraisal's fault and provide fair and reliable assessment result through grading that have correct standard and consistency to students.

Key words : Performance, Assessment, Self-directed Learning, Fuzzy Reasoning, Fuzzy Rule

1. Introduction

The 7th educational curriculum that has a purpose to foster autonomic and creative Korean who would lead the global information age is aimed at "quality control curriculum" on the basis of assessments to improve the differentiated education and self-directed learning ability. The assessment method that has been used in our education field till now was microscopic assessment such as written examination focusing on objectivity, reliability, and effectiveness. However, this assessment is difficult to grade the problem solving ability and higher thinking ability of the learner by focusing on only cognitive assessment that is simple and easy to measure. Also, it has the weakness that concentrates only the simple assessment focusing on learning by heart. As the method to complement this weakness, performance assessment has emphasized recently [1].

Performance Assessment includes the assessment method for estimator to observe the learning performance course and the result of the learners directly and to assess the result professionally, as well as the method to assess with all other methods beside the optional written examination [2]. Therefore, performance assessment should be understood and encouraged as "the assessment that is done in various ways through various data by the teacher in the course of education" [3].

Performance assessment is the overall approach method that can estimate all the cognitive and definitive characters, and has strong point to cultivate various thinking ability of the learner

by the liberal assessment method. However, several problems such as the difficulty of developing good assessment question, the fairness of estimation according to the possibility of estimator's fault, reliability, feasibility, ambiguity of the assessment standard, difficulty in securing objectivity etc. are arising in performance assessment [4].

To solve these problems of the difficulty in securing estimator's consistency, the fairness of grading, reliability rate, feasibility problem, and objectivity problem etc., that could be shown in performance assessment, this study proposes the performance assessment method using fuzzy membership function and fuzzy reasoning that can estimate the grades differentiated by the subject objectively, focusing on the subject of counting principle. Also, to sublimate the straight and unilateral assessment method of various performance result of learner and to supply the rule about details that is considered in performance assessment course and the accurate indicator for assessment, the fuzzy membership function is designed and the final performance assessment grade through fuzzy reasoning and defuzzifier is calculated. And it proposes the possibility to increase the reliability and feasibility by designing and implementing the performance assessment system using fuzzy in WBI(Web Based Instruction) with the object of accounting principle subject.

2. Related study

2.1 Performance assessment

2.1.1 the concept and character of performance assessment

The performance assessment is introduced as a link to secure the diversity and transparency of the assessment that is included in the plan, "education vision 2002, and new school culture creation" and it is a method to assess learner's knowledge, ability, and behavior etc. professionally from the course of learning performance and the result from it. The performance assessment system means "the assessment method to assess learner's knowledge, ability, and behavior etc. professionally from the course of learning performance and the result from it" [5].

The general character of performance assessment is as follows [6].

First, performance assessment is the method to make learner to write the answer or show in activity for him/herself, not to select the answer.

Second, performance assessment is to understand the actual circumstances as possible whether to achieve the educational aim that is pursued. Therefore, it is to assess in the way that can observe in actual circumstances rather than the way to make the learner to select the answer in abstract circumstances.

Third, performance assessment is the method that values much of the course of learning as well as the result.

Forth, performance assessment is the method to emphasize that is should be done overall and continuously to understand the course of changing and development of each learner synthetically.

Fifth, performance assessment thinks highly of the assessment of group to lead the corporation between each learner, although it used to estimate in the unit of each learner.

Sixth, performance assessment thinks highly of the efforts to examine the learning course of learners and to facilitate the individual study.

2.1.2 The problems in performance assessment

Performance assessment is the method of course-centered evaluation that the learner can solve problems actively, and useful in the aspect that it supplies learners or teachers the meaningful result for improvement of the lecture by understanding the overall ability of students accurately and reasonably. However, the rapid import to the school field without close examination and rumination about the possibility of actual application can cause lots of problems. Especially, the problem in objectivity and fairness of the result of performance assessment was considered to be linked with the confidential report of students, the object of evaluation, so it lost the reliability of the grading.

To improve these problems, the adaption of detailed assessment standard though subject discussion among teachers, opening of evaluation standard, peer-evaluation and self evaluation etc. are being done in various ways, but there are still the problems in objectivity, reliability and feasibility.

2.2 Fuzzy theory

2.2.1 The membership function of triangle type

As fuzzy group is used to express the individual subjectivity, in expressing the linguistic value, there are differences between individuals, but it is needed to be standardized for individual comparison. In this point of view, when dealing with fuzzy group, the standard parameter membership function that has controllable parameter is used. The membership functions such as triangle, trapezoid, and S type are the typical shape of standard parameter membership function having controllable parameters.

A is defined as fuzzy group, the subset of the universal set X. and the membership function of triangle type is same as the Figure 1, and defined as follows [7].

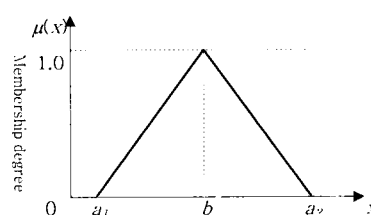


Figure 1. Membership function of triangle type

Where, x is input and $\mu(x)$ is the membership degree of the input x .

2.3 The existing performance assessment method using fuzzy theory

One character of performance assessment is that the subjectivity of teacher can be intervened in the circumstance of evaluation and it can be the cause of disbelief about the grading result of students. To improve these problems and secure objectivity, reliability and feasibility, that are the weak points of performance assessment, fuzzy performance assessment method that transformed the evaluation grades by subjective evaluation of teachers into the method by fuzzy grading table was proposed [8]. In this method, questions were consisted with 5 small questions that has different item difficult each. However, in this method, the appropriate question development to improve the effect of fuzzy grading table by the performance assessment fuzzy point.

3. The performance assessment method using membership function and fuzzy reasoning

The performance assessment that is operated with the import of the 7th educational curriculum is thought highly in the aspect that it can lead the self-directed learning through experiencing learning of learner and can evaluate the course of overall learning.

By the result of survey shown in "the study on operating performance assessment system in middle school" by Chung ho Kim, the biggest problem in performance assessment is the difficulty in mass operation, poor evaluation and fault in assessment respectively. Seeing from the result of these surveys, the performance assessment must be the most suitable method for the aim of the 7th educational curriculum, but there are difficulties in securing consistency of evaluator, fairness of grading, reliability, feasibility, and objectivity.

Fuzzy theory considers the causes that influences to the performance subjects of the grading method without consistency and subjective, and makes it objective to the grading standard for teachers to evaluate easily, and supply the method that can satisfy students about the result of performance assessment. In this study, the performance assessment method for high school accounting principle subject is proposed using fuzzy membership function and fuzzy reasoning.

The proposed method proposes the performance assessment method using fuzzy membership function and fuzzy reasoning, considering the causes that influence to the each area of high school accounting principle subject, and make possible the objective assessment of grades per subject by subjective evaluation of teachers by solving problems about securing consistency of evaluators through implementation of performance assessment on the web, improving the problems of fairness of grading, reliability, feasibility and objectivity. The method suggested among several performance assessment areas improves the problems in existing faults in grading through appropriate formation estimation and work reports by applying to the accounting principle subject. The reflecting ratio about accounting principle is defined as 60% of written examination, 40% of performance assessment. It can be changed through discussion for each subject. And as for the ratio of mark distribution, it is 30% in formation estimation and 10% in work reports.

The basic structure of performance assessment method using membership function and fuzzy theory proposed in this study is consisted with the part of fuzzifier, the part of reasoning, role base, defuzzifier and handling phase [9,10,11].

The part of fuzzifier changes the input data into appropriate linguistic value after abstracting the section of the value of input variables into the responding universal set. And the

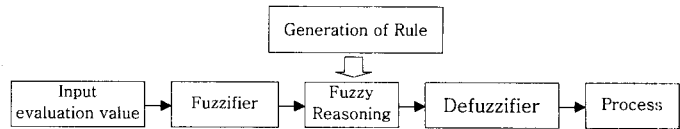


Figure 2. Map of the proposed performance assessment method.

linguistic value is fuzzified applying the membership function again.

The role base expresses the reasoning rule by arranging the knowledge about handling. At this stage, it expressed the reasoning rule created by experts and defines the linguistic rule.

The reasoning part is the activating part of mark evaluation using fuzzy theory; it calculates the fuzzy values similar to human thinking.

The part of defuzzifier defuzzifies by applying the center of gravity, as it can't use the output fuzzy value as the input of reasoning handling part.

3.1 Membership function design of formation examination considering the level of difficulty

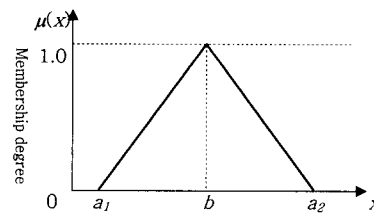


Figure 3. Membership function of triangle type

Where, x is input and $\mu(x)$ is the membership degree of the input x . Input x has membership degree in the section of $[a_1, a_2]$. If $x = b$, the membership degree would be 1. Therefore, for the section $[a_1, a_2]$, input x 's membership degree is decided as follows.

$$\begin{aligned} \text{if } (x \leq a_1 \text{ or } x \geq a_2) \text{ then } \mu(x) &= 0 \\ \text{if } (x \in [a_1, b]) \text{ then } \mu(x) &= \frac{a_2 - x}{a_2 - a_1} \\ \text{if } (x \in [b, a_2]) \text{ then } \mu(x) &= \frac{x - a_1}{a_2 - a_1} \\ \text{if } (x = b) \text{ then } \mu(x) &= 1 \end{aligned} \tag{1}$$

3.1.1 The membership function about formation examination considering of difficulty level

The first area of accounting principle performance assessment designs the membership function considering of the difficulty level about correct answer rate though analysis of the items in formation examination.

The number of questions in formation examination is 10, and it considers the difficulty level of questions when operating

formation examination. Difficulty level is to consider how many students get correct answer for a question. In education, difficulty level(p) is defined as follows [12].

$$\text{Difficulty level}(p) = \frac{r}{N} \quad (2)$$

r : the number of students answered rightly
n : the number of total students

Therefore, the value of difficulty level is between 0 and 1.

In this study, the difficulty level is divided into top(D1), middle(D2), and bottom(D3), and says the top that is the most difficult and the bottom that is the easiest.

In evaluating the questions that students get correct answer according to the difficulty level top, middle, bottom, it is evaluated by three levels of good(G), medial(M), and bad(B). If calling the number of questions of correct answer per each difficulty level as x, the membership function about it is as the Figure 4.

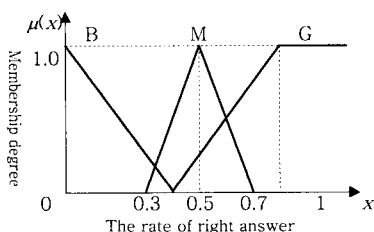


Figure 4. The membership function about formation examination according to difficulty level.

3.1.2 The reasoning rule about formation examination

The reasoning rule of performance assessment system is created by the knowledge or experience of experts. As the rule is reasoned by the form of IF~THEN as said in advance, the experience and knowledge can be used as the natural language.

The 27 reasoning rules reflected to formation evaluation is as the Table 1. it is verified to 5 steps of A, B, C, D, E by applying the fuzzy rules to membership function about formation examination according to the difficulty level. The reasoning rule can be adjusted little by experts or in the application example after designing system.

Table 1. The reasoning rules defined considering of difficulty level of Good, Middle, and Bad

Rule	D1	D2	D3	→	E	Rule	D1	D2	D3	→	E
Rule-1	G	G	G	→	A	Rule-15	M	M	B	→	D
Rule-2	G	G	M	→	A	Rule-16	M	B	G	→	C
Rule-3	G	G	B	→	B	Rule-17	M	B	M	→	D
Rule-4	G	M	G	→	A	Rule-18	M	B	B	→	E
Rule-5	G	M	M	→	B	Rule-19	B	G	G	→	C
Rule-6	G	M	B	→	B	Rule-20	B	G	M	→	D
Rule-7	G	B	G	→	B	Rule-21	B	G	B	→	D
Rule-8	G	B	M	→	C	Rule-22	B	M	G	→	C
Rule-9	G	B	B	→	D	Rule-23	B	M	M	→	C
Rule-10	M	G	G	→	A	Rule-24	B	M	B	→	E

Rule-11	M	G	M	→	B	Rule-25	B	B	G	→	C
Rule-12	M	G	B	→	C	Rule-26	B	B	M	→	E
Rule-13	M	M	G	→	C	Rule-27	B	B	B	→	E
Rule-14	M	M	M	→	C						

3.1.3 The membership function about the grades according to the 5 levels evaluation grades

After the students take the formation examination, by the fuzzy rule according to the difficulty level, it is divided into 5 evaluation levels of A, B, C, D, E, and if designing the membership function to change the grades into mark, it is expressed as the Figure 5. The full mark of formation examination is 30 points.

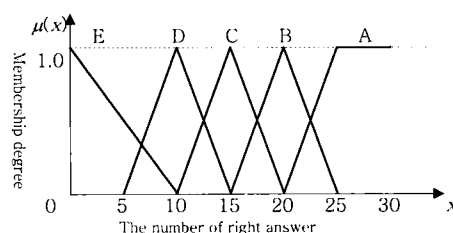


Figure 5. The membership function about grades according to the 5-level evaluation level

Where, the mark can be calculated by expressing the indefinite and linguistic 5-level as quantitative value through defuzzifier. The defuzzifier proposed in this study is calculated the quantitative mark by applying the center value defuzzifier method as the formula (3).

$$x^* = \frac{\int \mu_i(x) \cdot x \cdot dx}{\int \mu_i(x) \cdot dx} \quad (3)$$

3.2 Design of membership function about work report

The second item of performance assessment, work evaluation(report) is evaluated by having students to collect, analyze and synthesize data, and writes and submits the report after the teacher proposes a subject.

In this study, students are to hand in the work report after finishing a chapter of accounting principle, and as for the estimation about the work, teacher evaluates it with 10 points as much as it suits to each standard with three standards. The three standards of average marks are defined by teacher considering of the character of subject and the theme of the work. The evaluation of work takes 10% out of 40%, the distribution ratio of the total performance assessment.

3.2.1 The membership function about three standards of work evaluation

In evaluation of accounting principle subject, when students submit the work that they performed, teacher makes three

standards, evaluates the works how much those suit for the standards and makes those in the form of marks with the total point of 10. At this point, the three standards are defined as F1, F2, and F3. And teacher can set these three standards considering of the character of work and level of importance. As the subjectivity of teacher could be intervening in evaluating the works, it should be designed to prevent the fault in evaluation by applying the membership function about marks, and to improve the feasibility and reliability about evaluation.

In evaluating works, the evaluator, teacher evaluates by dividing into three levels of good(G), medial(M), and bad(B). The evaluator gives marks with total mark of 10 about the three standards and the membership function about this is as the Figure 6.

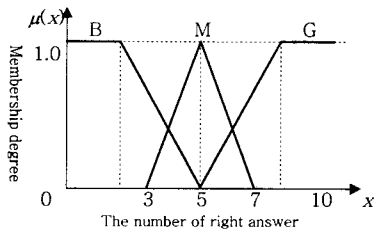


Figure 6. The membership function about three standards in evaluating works.

3.2.2 The reasoning rule about evaluating works

The evaluation of works is reasoned in the form of IF~THEN on the basis of experience and knowledge of experts same as the formation examination reasoning rule. The 27 reasoning rules reflected in work evaluation are as the Table 2. The membership function about three standards considered in evaluating works is divided into four levels of A, B, C, D, by applying fuzzy reasoning rule.

Table 2. The reasoning rules about evaluating works considering of three standards

Rule	F1	F2	F3	→ E	Rule	F1	F2	F3	→ E
Rule-1	G	G	G	→ A	Rule-15	M	M	B	→ C
Rule-2	G	G	M	→ A	Rule-16	M	B	G	→ B
Rule-3	G	G	B	→ B	Rule-17	M	B	M	→ C
Rule-4	G	M	G	→ A	Rule-18	M	B	B	→ D
Rule-5	G	M	M	→ B	Rule-19	B	G	G	→ B
Rule-6	G	M	B	→ B	Rule-20	B	G	M	→ B
Rule-7	G	B	G	→ B	Rule-21	B	G	B	→ C
Rule-8	G	B	M	→ B	Rule-22	B	M	G	→ B
Rule-9	G	B	B	→ C	Rule-23	B	M	M	→ C
Rule-10	M	G	G	→ A	Rule-24	B	M	B	→ D
Rule-11	M	G	M	→ B	Rule-25	B	B	G	→ C
Rule-12	M	G	B	→ B	Rule-26	B	B	M	→ D
Rule-13	M	M	G	→ B	Rule-27	B	B	B	→ D
Rule-14	M	M	M	→ B					

3.2.3 The membership function about marks according to the four-level evaluation level

When students submit the work, teacher evaluates it with three standards, and divide it into four levels of A, B, C, D, by the reasoning rule through fuzzy logic system. To change it into mark on the basis of the levels divided by reasoning, membership function as the Figure 7 is applied. The evaluation of work takes 10% out of 40%, the distribution ratio of the total performance assessment, and the highest mark of work is 10 and the lowest is 5.

As the formation examination that considers difficulty level, the mark is calculated by expressing in quantitative number about infinitive and linguistic four levels through defuzzifier, the defuzzifier method proposed in this study is used most commonly and calculate quantitative mark through centroid defuzzifier technology that can calculate accurate value.

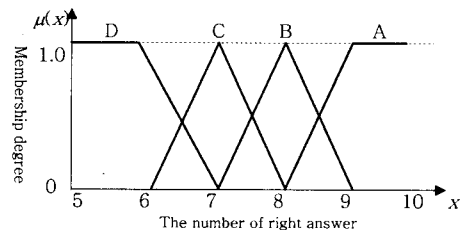


Figure 7. Membership function about marks according to the four evaluation levels

3.3 Map of the proposed performance assessment system

The map of performance assessment system using membership function and fuzzy reasoning proposed in this study is as the Figure 8.

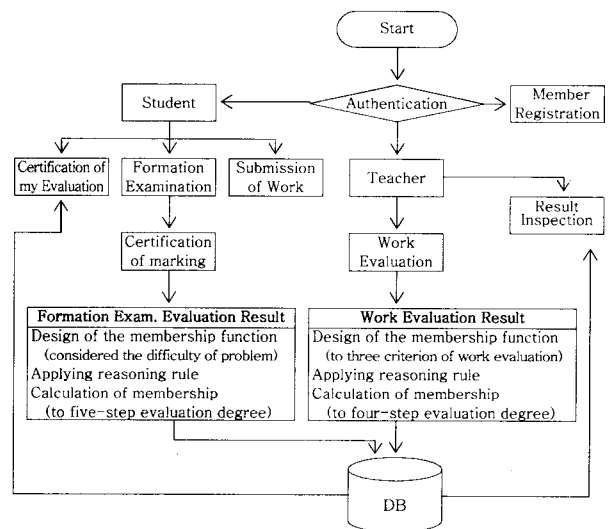


Figure 8. Map of proposed performance assessment system

4. Implementation and analysis

4.1 Design of database

DBMS built database using Microsoft Access. Database is consisted with the member registration table(Table 3) and work evaluation and formation examination result table(Table 4), and user id is defined as the primary key.

The Table 4 is the table about work and the result of formation examination. In the work evaluation, teacher analyze the work that student submitted and evaluate about the three standards of plow, pmid, and phigh, and then apply the membership function. And teacher divides it to four levels with pre-defined reasoning rule, and then save the mark of final work evaluation. In formation examination, teacher analyzes the difficulty level of questions and applies the membership function. And then teacher save the final mark of formation examination by dividing into 5 levels with pre-defined reasoning rule.

Table 3. Member registration table

Field Name	Data Type	Description
userid	Text	User's identifier (unique)
password	Text	User's password
id	Integer	Student identifier (unique)
name	Text	User's name
email	Text	User's e-mail address
tel	Text	User's telephone number
intro	Text	User description

Table 4. Work evaluation and formation examination result table

Field Name	Data Type	Description
plow	Integer	Work evaluation
pmid	Integer	Work evaluation
phigh	Integer	Work evaluation
mark	Integer	Final work evaluation
test 1	Integer	Answer check
test 2	Integer	Answer check
test 3	Integer	Answer check
test 4	Integer	Answer check
test 5	Integer	Answer check
test 6	Integer	Answer check
test 7	Integer	Answer check
test 8	Integer	Answer check
test 9	Integer	Answer check
test 10	Integer	Answer check
test	Integer	Formation examination final mark

4.2 Implementation

This performance assessment system is implemented to minimize the fault possibility of evaluator and increase the

fairness, reliability and feasibility of marking by creating rules through fuzzy membership function and fuzzy reasoning and dividing into final level, for formation examination and work evaluation considering of difficulty level with the object of accounting principle subject. The proposed performance assessment system is implemented with ASP and VB Script on IBM PC equipped with Intel Pentium-IV 77MHz CPU and 130MB RAM.

This performance assessment system is consisted with login, member registration, notice, accounting principle lecture and board.

Students who logged in through member registration can solve questions by approaching to formation examination in accounting principle lecture and confirm the correct and wrong answers of his/her own. Work should be submitted to the teacher directly, and the mark of work evaluation and formation examination can be confirmed in the individual learner's mark. Students confirm the correct and wrong answers after formation evaluation and save the result. At this point, this system calculate the final mark after defuzzifier and reasoning rule by calculating the difficulty level of questions for all students and apply membership function.

Supposing that the system analyzed the difficulty level of the question no.1 and decided it as high, it would be calculated as lower mark than the difficulty level middle or low. Therefore, even though the number of correct answer is same among 10 questions, the mark is different as it considers the difficulty level. The screen to confirm individual mark of students is as Figure 9.

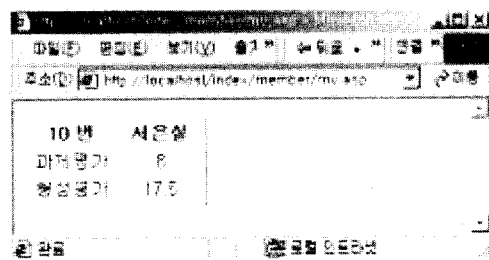


Figure 9. The screen to confirm my mark.

Teacher input the marks by applying three standards about works that students submitted in mark administration after logging-in as admin. Also, teacher can confirm student's mark of formation examination mark, and confirm marks of both formation examination and work evaluation at the same time according to the order of student.

Figure 10 is the screen that teacher confirms the final mark about formation examination and work evaluation for total students. The performance assessment system proposed in the case of formation examination calculate quantitative mark after calculating membership level considering difficulty level, applying fuzzy rule through fuzzy reasoning, and defuzzifier.

Also in the case of work evaluation, if teacher inputs appropriate mark about the pre-proposed three standards, system calculate the membership level and quantitative mark through defuzzifier by applying fuzzy rule by fuzzy reasoning.

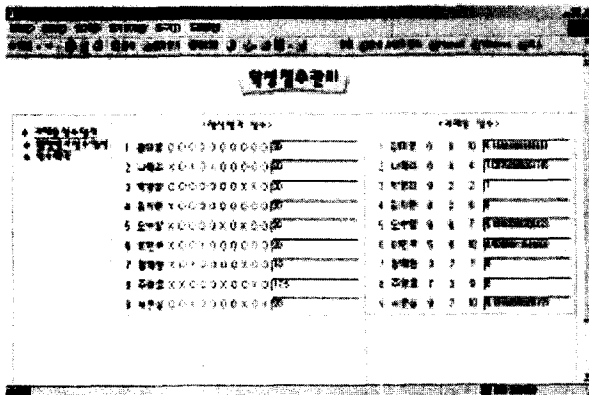


Figure 10. Screen of mark confirming about total students

4.3 The contents of survey analysis

In this study, the performance assessment about "the primary principle of accounting" with the subject of accounting principle of first grad in D girls high school and S girls high school of Busan for experimental analysis, and then survey was performed with 15 teachers and 100 students. The questions of survey were consisted with total 6 questions; 3 for teachers and 3 for students.

Table 5 is the result of analysis about the question "Can be this performance assessment system used usefully as the method for evaluation?" for teachers. 60% of the respondents answered yes and 27% so-so, and 13% answered no. As the result, it could be understood to be evaluated positively about this system.

Table 5. Availability as a method of performance assessment

Q1) Can be this performance assessment system used usefully as the method for evaluation?			
	Option	Respondent (Person)	Percentage (%)
(1)	Yes definitely.	3	20
(2)	Yes.	6	40
(3)	So so.	4	27
(4)	No.	2	13
(5)	Not at all.	0	0

Table 6 is the result of analysis about questions about the advantages of performance assessment system proposed for teachers. 60% of respondents were found to be satisfied with the easy and simple way of work evaluation and the calculation with high objectivity and reliability. However, the reason that the respondents about the method of formation examination through analyzing difficulty level is supposed to be the lack of

acquisition about the method of formation examination including the concept of difficulty level and the lack of understanding about the complex reasoning rule of this system for teacher.

Table 6. The advantage of the proposed performance assessment system

Q2) What do you think the best advantage of this performance assessment system?			
	Option	Respondent (Person)	Percentage (%)
(1)	Marking method of formation examination through analysis of difficulty level	1	7
(2)	Instant result calculation for students after formation examination and feedback	3	20
(3)	Easy and simple method to evaluate works	6	40
(4)	Calculation of evaluation result with objective and high reliability	5	33

Table 7 is the survey about satisfaction level about the performance assessment system proposed for students. 47% of respondents answered that they are satisfied with the result of performance assessment, 29% answered so-so and 24% answered no. Therefore, students were evaluating this system positively and the reason was the objective and fair evaluation about work evaluation, instant result calculation after formation examination and feedback.

Table 7. Satisfaction level about the proposed performance assessment system

Q3) Are you satisfied with the result of the performance assessment through this system?			
	Option	Respondent (Person)	Percentage (%)
(1)	Very satisfied.	15	15
(2)	Satisfied.	32	32
(3)	So so.	29	29
(4)	No.	17	17
(5)	Not at all.	7	7

5. Conclusions

The performance assessment that has been emphasized since the 7th educational curriculum started is highlighted as a method to overcome the limit of problem solving ability that is the problem of existing written examination and higher thinking ability and to normalize school education. However, it has problems such as the possibility of fault of evaluator, fairness and reliability of marking, feasibility, ambiguity of marking standard and difficulty of securing objectivity. To

solve these problems, an intelligent assessment method became to be required. Fuzzy theory supplies the assessment standard to overcome the subjectivity and infinity of teacher that is intervene in the course of performance assessment and the method with high reliability and feasibility.

This study proposes fuzzy performance assessment method with high objectivity and reliability through reasoning by analyzing the causes that influence to each area of performance assessment, designing fuzzy membership function, and defining fuzzy rule. Also, it designed the membership function by dividing the performance assessment question into formation examination and work evaluation in the proposed performance assessment method. The formation examination and work evaluation that are the subjects of performance assessment calculated the level of formation examination by analyzing the difficulty level of each question, designing the membership function for each levels, defining fuzzy rule with IF~THEN structure, and wit Max-Min reasoning. Also the level of formation examination divided through reasoning rule calculated quantitative mark by membership level by applying the membership function again.

The effect of the performance assessment system proposed through survey is to decrease the burden of appraisal fault about the calculated performance assessment result, and to supply evaluation with fairness and high reliability to students through accurate standard and consistency. Also it can give the effect to decrease the work of teacher with simple way of inputting marks in evaluating works of students.

The methods of performance assessment using fuzzy membership function and fuzzy reasoning proposed in this study would be extended to intelligent performance assessment system that can be applied to several subjects.

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