The Use of Fuzzy Logic in Pedagogy of Gifted Students

1 Introduction

There are a lot of definitions which describe giftedness from different attitudes. For this article the most well-known definition from 1972 could be used. It originated in the report of a school inspector Marland dealing with the condition of education of very able students in the USA. "The gifted and talented children are identified by professionally qualified persons as children who are capable on the base of outstanding abilities of high performance. These children require differentiated educational programs and offers beyond the scope familiarly provided by classical education program if they should be useful themselves and the whole society"(Webb, 1994, p.3). The children who are capable of high performance include those who present the prosperity or potential in any (one or more) of the following areas:

- o General intellectual ability.
- o Specific academic aptitude.
- o Creative or productive thinking.
- o Leadership ability.
- o Visual and performing arts.
- o Psychomotor ability.

They have distinctly different learning pace, different quality of performance, deeper and broader interests in the area of their talent in comparison with average population. Their educational needs come from these exceptionalities which are projected to specific educational approach. This education could be realized in three basic forms: segregation, integration and their temporary forms. Placement of gifted students in some of these educational programs mostly depends on their individual needs. Let's focus on segregated forms, it means the forms in which a gifted pupil is inserted in special learning group, class or school.

2 Some methods of selection of gifted children

The selection of gifted is a process of searching of children, whose preconditions are good for an insertion in a special education offer. It means that the selection concentrates on children, who were identified as gifted and who demonstrate high achievements in some area (Hříbková, 2005). This process usually appears during the entrance to special education, for example schools for very able, high schools, sports clubs or schools for children with extended educational needs. The use of concrete methods depends on the type of talent that is the main object of identification, on the model of gift and educational offers of special school and on other components such as a number of candidates, their age or school possibilities. We could use traditional psychological, pedagogical and medical methods of selection, which will be briefly described.

The most popular methods are intelligence tests. According to some specialists the tests came under strong criticism because of their inability to incorporate all components of intelligence. Another problem is based on their construction because the test is suggested for average population and the test on the higher level of intelligence has not good differentiation – so called ceiling effect (Mackintosh, 2000). Also the tests administration could be stressful for children, because they must perform well in a short time. Careful interpretation of results is necessary in this case. We discover general intellectual ability by using these tests. In case of other abilities we use it as a complementary test. However Dočkal (2005) states that adequately developed general intelligence is necessary for any kind of talent.

The educational tests are another common approach to select gifted students. These tests are usually used by school system and measure children´s ability in specified area of knowledge. Some tests exist for measuring specific talents, for example music or sports ability, specific academic ability or various fields of creativity. Information about successful participation at competitions could bring similar results. Very important place among selecting methods has information about child's motivation. We get it by dialogue, questionnaire or observing. The dialogue is often completed by information about interests and energy for doing some activities.

Other psychological methods are creativity tests which measure the level of divergent thinking. They describe originality, flexibility and quality of ideas. Such exams could describe various types of creativity, for example verbal, spatial or musical. There are a lot of commercially developed tests but it is evident that teachers could create their own tests without problems. Some imperfections can be found in difficult evaluation and their fast outdating.

School marks are often used as an indicator of talent and for selecting children. But we must not forget that school results are very individual and they are different at each school. It is known that gifted children have not he best school marks and that is why it is recommended to use this method alternatively. Other methods could be analysis of pupil's portfolio, teacher's recommendation, and scales for rating of behavioral characteristics and in case of sport talent special anthropometric measuring or other medical methods. We should not forget about lay methods, especially focused on observation.

3 Used methodology for selection of gifted students

If we choose suitable methods and collect necessary information about children, we should focus on selection. We get the total result by combination of partial results of every used method. The most frequent models are those, where the main condition is passing all exams (wide model) or only one of them (deep model) (Mesárošová, 98). In our opinion both these models are not suitable for selection in an extreme form.

The adequate selecting model should always contain every criterion. But the main problem is how to combine these values. The simplest way is to add all parts together. That is done very frequently during the student admission. The selection commission decides the minimum numbers of points for acceptance of applicants. It could happen that pupils or students with insufficiently developed ability enter special education which is during the addition neutralized with another developed ability.

How could we eliminate these methodological imperfections? Dočkal (1999) offers resolution of multiplying all variables. In our opinion this model is not suitable. In case of extreme deficit of one of the abilities and extra level of other abilities will not be enough to reach the successful results. This model is less suitable, because it could not take these problems in their substance. That's why we offer to use the theory of fuzzy logic, which allows working with vague concept.

4 Suggested methodology of selection of gifted students

The real phenomena in nature and society are very complicated. The description of these phenomena is even more complex. Among social phenomena it is possible to include psychological, financial, political ones, but also phenomena and processes in pedagogy. The founder of fuzzy logic is Lotfy Zadeh. He defined the fundamental of fuzzy logic in his theory which was published in 1965. The word fuzzy means dull, misty, infinite, and vague. These synonyms match also the content of fuzzy theory. This theory wants to cover the reality in their inaccuracy and uncertainty. The fuzzy logic works with vague notions at inputs and outputs. The example of accurately measurable input variable can be mentioned in pedagogy, the number of reached points in a didactic test. The decisive majority of input variables cannot be described exactly in pedagogy, we can set up them vaguely (this process is called fuzzification). We can mention the evaluation of creativity as an example - small, medium, high, etc. The output variable can be presented by evaluation in the form of vague notions, e.g. keen, talented, very talented students (this process is called defuzzification). These mentioned examples present the fitness of using of this theory, when we want to reach quality methods of evaluation in pedagogy. The fuzzy logic works with the rules (this process is called fuzzy inference). See fig.1. The fuzzy rules are based on notions "When", "And", "Or", "Then", "Else".
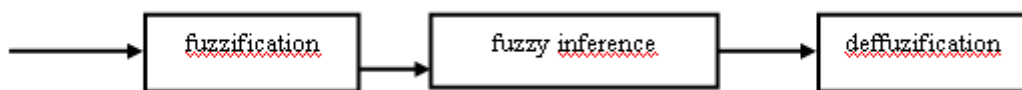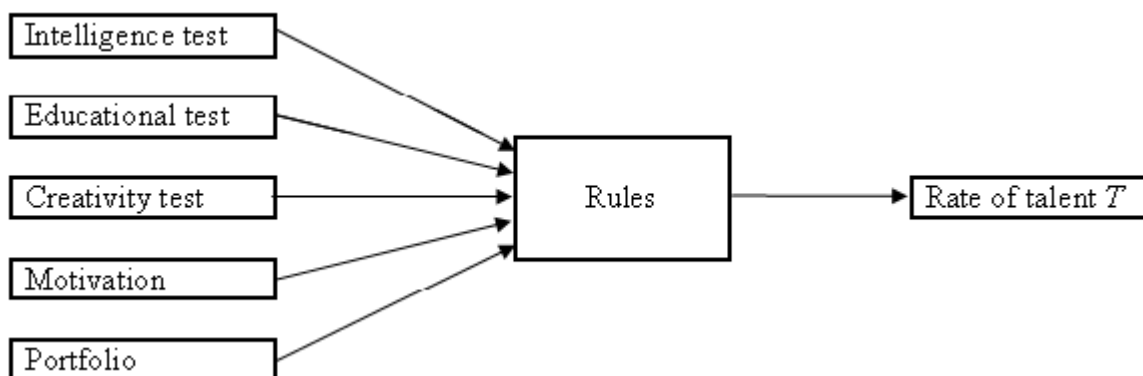

Fig.1 Fuzzy processing of pedagogical phenomena

Complicated examples can be solved by commercially sold programs, such as FuzzyTech of INFORM GmBH firm. We can use the Excel program of Microsoft firm in this case. We suggest the fuzzy model that evaluates the input variables: Intelligence test, Educational test, Creativity test, Motivation (motivation talk), Portfolio and the output variable: Rate of talent T. See fig.2.

The input variables Intelligence test, Educational test and Creativity test have seven attributes (features, properties) defined by vague notions: Disability, Under average, Average, Mild average, Added average, High average, Very high average. The input variables Motivation and Portfolio have five attributes: Disability, Under average, Average, Mild average, High average. The output variable Rate of talent has five attributes: Very high, High, Medium, Low, Very low. The membership functions of all attributes are linear.

Intelligence test

Educational test

Creativity test

Motivation

Portfolio

Rules → Rate of talent T

Obr.2 Fuzzy model

The transform matrix *TM* which numerically expresses the relation of rate of ability of single input variables can be defined under these conditions. It is necessary to set up the table on the basis of own experience or experience of experts. See tab.1. The graphs in table present the linear dependence of membership functions which is not prerequisite. E.g. we can evaluate the dependence to be non linear.

	Intelligence test	Educational test	Creativity test	Motivation	Portfolio	
1-Disability	0,0	0,0	0,0	0,0	0,0	8-Disability
2-Underaverage	16,6	16,6	13,3	20,0	12,5	9-Underaverage
3-Average	33,2	33,2	26,6	40,0	25,0	10- Average
4-Mild average	49,8	49,8	39,9	60,0	37,5	11-Mild average
5-Added average	66,4	66,4	53,2	80,0	50,0	12-High average
6-High average	83,0	83,0	66,5			
7-Very high average	100,0	100,0	80,0			

Tab.1 Transform matrix *TM*

The state matrix *S* determines the rate of ability of single input variables for concrete case. This table must be completed on the basis of capabilities of investigated student. For example the student reached in Intelligence test - Added average, Educational test - Mild average, Creativity test - Average, Motivation - Mild average and Portfolio - Under average. See tab.2.

	Intelligence test	Educational test	Creativity test	Motivation	Portfolio	
1						8
2					Yes	9
3			Yes			10
4		Yes		Yes		11
5	Yes					12
6						
7						

Tab.2 State marix *S*

Scalar product of transform matrix *TM* and state matrix *S* calculates the Rate of talent *T*. (The scalar product is defined as a sum of multiplies of corresponding cells in Excel program, which differs from

mathematical definition). It is possible to define retransform matrix RM_a according our needs. The retransfer matrix transfers the numeric value of Rate of talent T of student to linguistic value. See tab.3.

Rate of talent	Very high	High	Medium	Low	Very low
T	$R >= 90$	$90 > R >= 75$	$75 > R >= 60$	$60 > R >= 40$	$R < 40$

Tab. 3 Retransform matrix RM_a

Another way of evaluation is presented in tab.4, where the retransform matrix RM_b retransforms the numeric value of Rate of talent T of student to linguistic value Entrance-Yes, Entrance-No.

Entrance	Entrance-No	Entrance-Yes
T	$R <= 60$	$R > 60$

Tab.4 Retransform matrix RM_b

In our case (the symbol Yes in the cell must be converted to the value 1, other values are 0) the result of scalar product of transform matrix **TM** and state matrix **S** gives the value of Rate of talent $T = 66,4+49,8+26,6+60+12,5 = 215,3$ (the zero values give the zero result of multiplication and are not displayed). When we make the standardization of this value in the interval from 0% to 100% (the maximum value of scalar product is 410 points) we obtain the value 52.5%. This value means that the talent of students is low and the student will be rejected. See tab. 3 and 4. Other students have different evaluations. It is possible to make an evaluation of many students and to carry on their comparison by means of Excel program, as is it presented on fig.3.
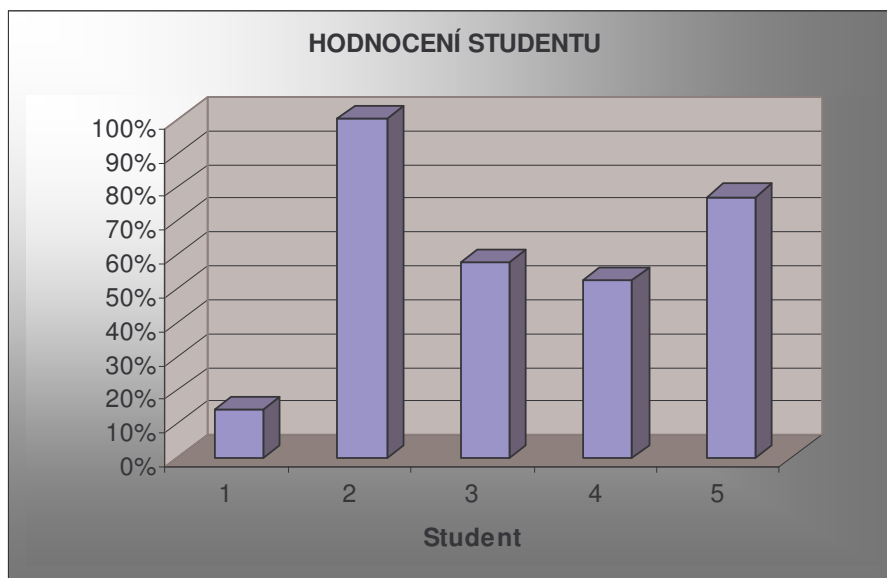

Fig.3 Evaluation of rate of talent of five students

5 Conclusion

The decision making processes in pedagogy belongs to activities identified as a multi-criteria and difficult for algorithm development. The presented methodology can be used in the process of evaluation of rate of talent of students, at entrance examination at schools and universities or other similar problems of decision making in pedagogy. The advantage is that the fuzzy logic works with vague notions which occur in the area of pedagogy very often and the evaluation by other methods is very difficult or impossible. Further meaning is the fact that we can evaluate a great number of students at the same time and use many input values (criteria).