Chapter 5
Application of Neutrosophic Sets to Assessment of Student Learning Skills

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ABSTRACT

Assessment is a very important component of education, because it helps the instructor to determine student mistakes and to improve student performance by reforming his/her teaching plans. Various assessment methods under fuzzy conditions (with qualitative grades) are presented in this Chapter, developed in earlier author's works. The first method, termed as the Rectangular Fuzzy Assessment Model (RFAM), is based on the Center of Gravity (COG) defuzzification technique. The outcomes of RFAM, which evaluates a group's qualitative performance, are compared to those of the classical calculation of the Grade Point Average(GPA) index. A method using triangular fuzzy numbers as assessment tools is also presented and it is proved to be equivalent with an analogous method using closed real intervals (grey numbers) as tools. These two methods, which are equivalent to each other, evaluate a group's mean performance. Further, a hybrid assessment approach is developed using grey numbers, neutrosophic sets and soft sets as tools, which is applied for assessing student learning skills.

INTRODUCTION

Assessment is a very important component of Education, because it helps the instructor to determine student mistakes and to improve student performance by reforming his/her teaching plans. The assessment processes are realized by using either numerical or linguistic (qualitative) grades, like excellent, good, moderate, etc. Traditional assessment methods are used in the former case including the calculation of the *mean value* of the student numerical scores and the calculation of the *Grade Point Average (GPA) Index*, which is a weighted average of the student scores (Voskoglou, 2017, Chapter 6, p. 125). The first method evaluates the *mean performance* of a student group, whereas the second one evaluates

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its *quality performance,* where greater coefficients (weights) are assigned to the higher student scores. In many cases, however, the use of numerical scores is either not possible (e.g. in case of approximate data) or not desirable (e.g. when more elasticity is required for the assessment). In such cases assessment methods are frequently used which are based on principles of *fuzzy logic (FL)*.

A great part of the present author's earlier research was focused on developing such kind of assessment methods, most of which are reviewed in (Voskoglou, 2019a). More recently, he introduced also a new technique for assessment in a parametric manner using soft sets as tools (Voskoglou, 2022a). It seems, however, that proper combinations of the previous methodologies could give better results; e.g. see (Voskoglou, Broumi & Smarandache, 2022).

In this chapter we present some important assessment methods under fuzzy conditions (with qualitative grades), which were developed in author's earlier works. We also present a hybrid assessment approach using closed real intervals (grey numbers), neutrosophic sets and soft sets as tools and we apply it for assessing student learning skills. The rest of the Chapter is organized as follows: The Mathematical Background section contains the necessary information about fuzzy sets and logic, triangular fuzzy numbers, grey numbers, neutrosophic sets and soft sets needed for the understanding the rest of the chapter. The next section (Main Focus of the Chapter) sketches the Rectangular Fuzzy Assessment Model and compares it with the classical GPA index. The method of using triangular fuzzy numbers as assessment tools is also presented and is proved to be equivalent with an analogous method using grey numbers as tools. Finally, the already mentioned hybrid assessment method is developed. The Chapter closes with some hints for future research and the final conclusion.

MATHEMATICAL BACKGROUND

Fuzzy Sets and Fuzzy Logic

The development of human science and civilization owes a lot to Aristotle's (384-322 BC) *bivalent logic (BL)*, which was in the center of human reasoning for centuries. BL is based on the "Principle of the Excluded Middle", according to which each proposition is either true or false. Opposite views, however, appeared also early in the human history supporting the existence of a third area between true and false, where these two notions can exist together; e.g. by Buddha Siddhartha Gautama (India, around 500 BC), by Plato (427-377 BC), more recently by the Marxist philosophers, etc. Integrated propositions of multi-valued logics reported, however, only during the early 1900s by Lukasiewicz, Tarski and others (Voskoglou, 2019a, Section 2). According to the "Principle of Valence", formulated by Lukasiewicz, propositions are not only either true or false, but they can have intermediate truth-values too.

Zadeh (1965) introduced the concept of *fuzzy set (FS)* as follows:

Definition 1: Let U be the universe, then a FS F in U is of the form

$$F = \{(x, m(x)): x \in U\} \quad (1)$$

In equation (1) m: U→ [0,1] is the *membership function* of F and m(x) is called the *membership degree* of x in F. The greater m(x), the more x satisfies the property of F. A crisp subset F of U is a FS in U with membership function such that m(x)=1 if x belongs to F and 0 otherwise.