ASSESSEMENT OF DISTANCE EDUCATION QUALITY USING FUZZY SETS MODEL

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Abstract *¾ In recent years distance education gained increased attention because of the advances in communication technology. As the number of institutions offering Internet-based distance education increases, it becomes a pressing task to evaluate, compare, and judge the quality of the education offered from different points of view. An attempt is made here to ease the difficulty of meaningful comparisons of engineering distance education by employing a model that maps the various ways we think about quality into a computer algorithm. Comparisons can then be automated leading to consistent and justifiable results. The model outlined here is based on the concepts of fuzzy sets with the objective of putting the data available on distance education offered by various institutions to a systematic use.*

Index Terms ¾ Distance Education, Fuzzy sets, Quality Assessment.

INTRODUCTION

Although there is a consensus among educators that quality is an important trait an educational institution must pursue, there is no such agreement on the definition of quality or how to measure it [1]. Concerns about quality intensified as distance education based on the Internet became more popular [2]. Information about various distance education providers is easily obtainable [2], nevertheless it cannot be tailored to the needs of a wide range of users. The overwhelming amounts of data can even be confusing from the point of view of judging quality.

The model presented here builds on the idea that comparison of classroom engineering education quality can be achieved using fuzzy sets concepts [4]. The objective of the model outlined here is not to measure quality or convert *quality* into a *quantity*, but rather to produce a figure-of-merit based on a given way of thinking. The central idea is to examine how an individual thinks about quality, then map that way of thinking, using fuzzy sets, into a computer algorithm. A program can then be developed to enable individuals to tailor the available information and compare the quality of education based on their points of view.

It is hoped that the methodology described here would be of interest not only to software developers but also to individuals and organizations interested in effectively using the data available on Internet-based distance education and determine what information is important to investigate or ask for its disclosure. It should be also of interest to institutions providing Internet-based distance education to prepare for quality assessment.

FUZZY SETS

Humans do not think in binary terms. In general, we realize that things occur in degrees; fuzzy sets enable computers to map this way of thinking [5]. Quality is not either high or low only; for example, we may describe it as very high, high, adequate, low, and very low. An objective of fuzzy sets is to make computers think like humans [4]. A classical (crisp) set is a collection of objects that have a common trait. One may associate with every crisp set S, a membership value $m_S : U \to \{0,1\}$ to every element in the universe of discourse U. A value of 0 is assigned if the element does not belong to the set and a value of 1 is assigned if the element belongs to the set. A fuzzy set F, on the other hand, is described using a membership function $m_F : U \to [0,1]$. Each element x in the universe of discourse U is assigned a degree of membership $m_F(x)$ in the continuum $[0,1]$. A fuzzy set allows degrees of belonging and hence maps our views better than crisp sets.

To illustrate the idea of fuzzy sets, suppose we want to select a comfortable house for three from a group of available houses based on the number of rooms in each house. The label *comfort* can be translated to a fuzzy set which is a collection of the number of rooms available in each house with every number associated with a value from zero (no comfort) to one (complete comfort) to represent the degree of comfort as we think about it. We can then write the set

$$\text{COMFORT} = \{1/0, 2/0.6, 3/1, 4/0.7, 5/0.3\} \quad (1)$$

The set defined by (1) reflects the way of thinking that three rooms lead to complete comfort, two, four, and five rooms are somewhat comfortable, and one room is not as comfortable. Other individuals may think differently and assign the membership values accordingly.

The union and the intersection of fuzzy sets A and B are fuzzy sets defined by (2) and (3) as follows.

$$m_{A \cup B}(x) = \max\{m_A(x), m_B(x)\} \quad (2)$$

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$$m_{A\cap B}(x) = \min\{\, m_A(x), m_B(x)\} \quad (3)$$

The complement of a fuzzy set A is defined by (4).

$$m_{\neg A}(x) = 1 - m_A(x) \quad (4)$$

There are operations that do not have counterparts in crisp sets such as Concentration and Dilution where the membership function is raised to a power α with $\alpha > 1$ and $0 < \alpha < 1$, respectively.

Fuzzy logic uses fuzzy sets for reasoning. The fuzzy AND, OR, and NOT correspond to the union, intersection, and complement of fuzzy sets, respectively. Mimicking human reasoning is attempted through a set of rules in the form of:
IF A THEN B. A fuzzy relation R has a membership function $m_R(x, y)$ that provides strength of correlation between every x and y. One's actual inference or firing of the rule is numerically emulated via *fuzzy modus pones* [5], which may be stated as: "given that $A \rightarrow B$, and given x as an approximate A; we infer an approximate B with maximum degree of fulfillment not greater than the degree of similarity between x and A". The result is reached by computing the membership $m_Y(y)$ employing the commonly used max-min inference operation defined as

$$\max\{\min\{\, m(x), m_R(x, y)\}\} \quad (5)$$

In order to apply these concepts to obtain a numerical representation of quality for the purpose of comparison we need to examine the elements of distance education quality, then describe each as a fuzzy set from a given point of view. Quality, the output, can be inferred in a way that reflects our thinking. But first we have to examine what is meant by Internet-based distance education.

INTERNET-BASED DISTANCE EDUCATION

One of the sources of conflicting opinions about Internet-based distance education is that the term distance education (and distance learning) means different things to different people. For clear focused discussion, it becomes important to examine what is meant by distance education; it may refer to [7]:

- Free lectures, courses, and resources covering the basics offered through institutions, industry, or the government as a public service or to attract attention. There are no obligations on either the contributors or the learner to do anything specific.
- Free lectures, courses, and resources for practicing engineers on current topics to provide up-to-date information, usually offered by industry.
- Stand-alone courses, lectures, etc. offered by various organizations for a fee. They do not lead to a degree, but may be used to satisfy requirements set by an employer or a licensing agency.
- Lecture notes, exercises, study aids, etc. distributed by the classroom instructor as a matter of convenience (mainly the instructor's convenience).
- A curriculum offered for a fee that has a mixture of classroom and Internet-based courses.
- A curriculum offered for a fee and leads to a degree (graduate or undergraduate), with all the courses being Internet-based. This mode is of particular importance in cases where student population is widely distributed geographically, distance learning in such cases could be the only affordable option.

Although the fuzzy sets methodology can be applied to all categories, the emphasis here is on the last category.

ANALYSIS OF CONTRIBUTING FACTORS

Factors that contribute to the quality of Internet-based education can be categorized into three inter-related groups that correspond with administrative, academic, and student success issues. The importance of each of these factors depends on the purpose and views of the assessor. The following is a short account of these factors.

Administrative

- Admission Requirements
  These include prerequisite skills and academic qualifications in addition to entrance examination evaluation. Lax requirements do not inspire confidence and harsh requirements can be a hurdle.
- Technical Requirements
  These address the hardware, software, and the level of technical knowledge to start the academic program.
- Learners' Support Services
  These include technical help in addition to academic counselling and tutoring.
- Fees
  It is not just how much, but also for how long, and how often, in addition to how the transactions take place.
- Financial Aid
  The availability of financial aid to the learners is an issue of concern [8]. The current status based on the applicable regulations has to be clear and its importance assessed.
- Enrollment
  Although a large enrollment in a program may contribute to its credibility, it can also mean reduced availability of faculty members to students.
- Faculty Support
  This includes technical support for hardware and software required, secretarial support, and tutorial services. The provision of such services would lead to more time being available for faculty members to

interact with students, but it increases the overhead expenses and hence the fees students pay.

Academic

- Faculty Members Qualifications
  These include formal education, work and teaching experience, in addition to research and scholarly activities. Such activities indicate current knowledge but may imply less time and interest in teaching.
- Interactions
  It has been shown that student learning is affected by student-student interaction, student-instructor interaction, and the time spent on task [9]. Internet-based distance education schemes provide for such interactions to varying degrees and using variety of platforms.
- Delivery Structure
  This relates to the accessibility of academic resources, the availability of elective courses, and the time frame to complete the work, in addition to the structure of laboratory work.
- Curriculum
  The key issues here are what outcomes are expected and how they suit a particular goal. The mechanism and frequency of updates are also important.
- Learners' Assessment
  This refers to the mechanisms by which the work and level of competency of the learners are assessed and whether the assessment is Internet-based or face-to-face, in addition to performance expectations.

Student Success

- Accreditation
  The result of assessment of the whole program by an independent professional body can enhance the credibility of graduates and enhance their chance of employment and acceptability in professional organizations. It may not be crucial for educational providers with a well-established track record. It may lead to increased bureaucratic work at the expense of student learning.
- Completion Rate
  The rate of completion and reasons for attrition can help students assessing their chances of success and funding agencies determining the credibility of the program.
- Employability of Graduates
  Simply expressed: how many of the graduates find employment based on their Internet-based education? How soon? For how long and at what salary?

APPLICATION OF THE FUZZY SETS MODEL

Each of the factors discussed in the previous section can be expressed as a fuzzy set. A general form, for simplicity, may be used to define a fuzzy set for each of the descriptors. A possible form could be: {Very_High/a, High/b, Adequate/c, Low/d, Very_Low/e}, where a, b, c, d, and e are numerical values between 0 and 1 assigned based on the user's judgment on the relative importance of the factors motioned earlier and the data available on them from various institutions. These fuzzy sets may be combined using fuzzy operations to reach a numerical value that describes a figure-of-merit for quality of education to be used for comparison purposes. An algorithm based on this model is expected to allow the user to enter more linguistic descriptors and their fuzzy set definitions. The fuzzy sets would vary from one user to another. For example, a prospective student may find the financial aid and employability to be extremely important. A government agency, on the other hand, may be more interested in the Fees, Enrollment, and Completion Rate.

CONCLUDING REMARKS

A methodology was presented in this paper to compare and judge the quality of Internet-based distance education offered by various institutions and education providers. It takes into account the various views on quality based on the purpose of the assessor. The methodology can lead to an automated process of quality comparison. Even if one is not interested in automating the process of quality assessment, thinking about quality guided by the concepts of fuzzy sets is by itself a useful exercise to reach an insight into the factors that could influence the quality of Internet-based distance education.

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