KNOWLEDGE-BASED EVALUATION OF HIGHER EDUCATION INSTITUTIONS

Janez Benkovič[1], Marko Bohanec[2], Vladislav Rajkovič[3,2], Metka Vrtačnik[1]

[1] *University of Ljubljana, Faculty of Natural Sciences and Engineering, Vegova 4, SI-1000 Ljubljana, Slovenia*
[2] *Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia*
[3] *University of Maribor, Faculty of Organizational Sciences, Prešernova 11, SI-4000 Kranj*
E-mail: j.benkovic@uni-lj.si

Abstract: The paper presents an approach to the evaluation of higher education institutions. The approach is based on the multi-attribute decision making software package Decision Expert (DEX). Higher education institutions and related performance indicators are represented by a tree of attributes. DEX is used for development and verification of the knowledge base, evaluation of attributes and interpretation of results. Expert system and artificial intelligence elements are introduced by representing the knowledge in order to allow qualitative analyses of soft data. For an example, a tree with 26 basic and 12 aggregate attributes was defined and four randomly selected institutions were evaluated. *Copyright © 1998 IFAC*

Keywords: Education, Quality, Evaluation, Artificial intelligence, Expert systems

1. INTRODUCTION

Now, at the end of 20th century many developed and less developing countries are reforming their entire educational system. One of the important feature of this change is the evaluation of higher education institutions (Kells, 1993). The importance of quality is increasing with the number of enrolled students in higher education institutions. A consequence of expansion is an engagement of substantial financial means for higher education, and this calls for stricter social control of money flow (Kump, 1994). Quality assurance has been introduced at universities and accepted as a regular university practice in many countries. They take various forms, such as habilitation procedures and exams. An integral part of quality assurance is quality control which must result in accountability towards customers and stakeholders, and self-evaluation of study programmes and university staff (Frazer, 1994). External evaluation of universities could be carried out in different ways: (1) by means of audit (meta-evaluation), (2) assessment, and (3) accreditation. A three-stage approach to evaluation of higher education institutions has been introduced (Fig. 1), comprising the following steps: (1) self-evaluation at the particular level, (2) peer review involving site visits, and (3) preparation of a report. In this report, quality is presented in written form and is sometimes supported by numerical facts whenever available and appropriate.

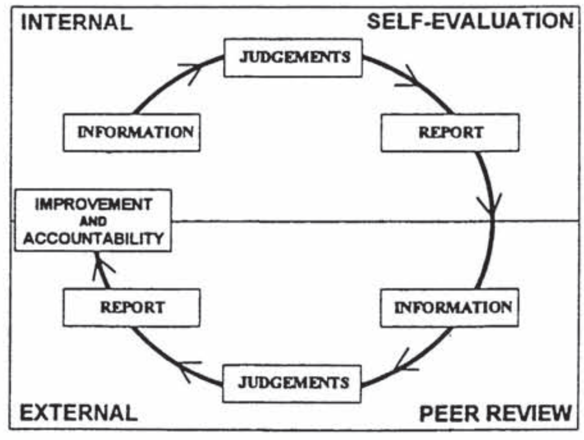

Fig. 1. Model relating self-evaluation and peer review (Frazer, 1994).

In the quality report, it is important to distinguish between two types of information. The first is pertinent to a particular higher education institution and reflects its overall state. The second type is reference information which could be used for comparison of different higher education institutions. The combination of both types of information could be used for drawing conclusions on the role and state of the higher education institution in a country (Brennan, 1994).

Performance indicators are an aid in evaluation. Higher education is a very broad and delicate field, therefore many parameters must be taken into account simultaneously in evaluation procedures. Nevertheless, it is practically impossible to encompass and express all external in internal influences on the quality in the form of indicators. It is even more difficult to follow up the process of quality control and to draw appropriate conclusions. Although one may reduce the complexity of the quality control process, one should avoid losing relevant information for objective value-added judgements.

Due to the dynamic changes in higher education institutions (new study programmes, reorganisation of an educational system), simple statistical figures are insufficient for drawing value-added judgements. The decisions on future development must be based on more complex analyses of performance indicators (Irvine, 1989).

Specially designed computer tools are available for information processing of manifold performance indicators. Decision expert (DEX) is one of such tools. DEX is an expert system shell which can be used for developing and testing a multi-attribute knowledge base as well as for the interpretation of evaluation results (Bohanec and Rajkovič, 1990). DEX uses a multi-attribute approach combined with elements of expert systems and machine learning. The basic approach lies in decomposing the overall decision problem into sub-problems. In this work DEX was tested for its capability and appropriateness for supporting the evaluation procedures of higher education institutions.

2. KNOWLEDGE BASE CONSTRUCTION

Higher education in the Republic of Slovenia is regulated by a recently passed Higher Education Law, which includes the prerequisites for carrying out the quality assurance procedure (Zgaga, 1994). In Slovenia there are two universities with 29 faculties, 3 academies of art, 4 professional higher education institutions, and 7 free-standing professional higher education institutions. They differ in organisational as well as programme schemes. At the university level it is therefore more difficult to introduce unified criteria and rules as it is the case elsewhere in larger countries where the universities can be compared with each other.

The evaluation procedure is carried out by a group of experts (peers). The expert group uses information and data from different sources in preparing the final evaluation report. The selection of indicators depends on the goals and objectives of the evaluation. The stress in evaluation procedure could be either on internal organisation of higher education institution or on international comparisons.

The final quality report could be prepared by a group of experts by using the results provided by DEX. This group is responsible for defining and selecting performance indicators, which are then represented as attributes in a DEX knowledge base. The attributes are organised in the form of a tree. The leaves of the tree are specific and simple attributes that can take one of 2 to 5 possible qualitative values. To insure a better, quicker and clearer evaluation procedure, both the attributes and their values must be clearly defined and described. Also, the effect of a particular attribute on the overall result of the evaluation procedure is estimated, and accessibility of data for its evaluation is verified. This includes the verification of the transformation of raw data on a particular attribute into a comparable performance indicator. For example: it is necessary for some performance indicators to use average values instead of absolute ones. In most cases, attribute values are normalised. For example, the attribute "number of books" is obtained by dividing the actual number of books by the number of students. For the attribute "research" the number of gained points obtained for research work is divided by the number of research staff.

Performance indicators can either be included in, or omitted from, the pool of indicators. This is decided by the expert group. Elementary attributes are further combined into aggregate attributes, resulting in a tree of attributes for the evaluation of institutions.

In the work reported here, the performance indicators most often described and discussed in literature (Berg, 1994; Fernandez, *et al.*, 1993) were selected. A part of the developed tree structure is shown in Fig. 2.

Components of the tree, and later changes, are introduced interactively into DEX. In our test, 26 elementary attributes were chosen and combined into 13 aggregate attributes.

The values of aggregate attributes are determined by means of utility functions. These functions are represented by decision rules defined by experts for each combination of elementary attribute values of the descendants in the tree structure. DEX supports the definition of rules by generating all possible combinations of attribute values and assessing the consistency of the knowledge base.

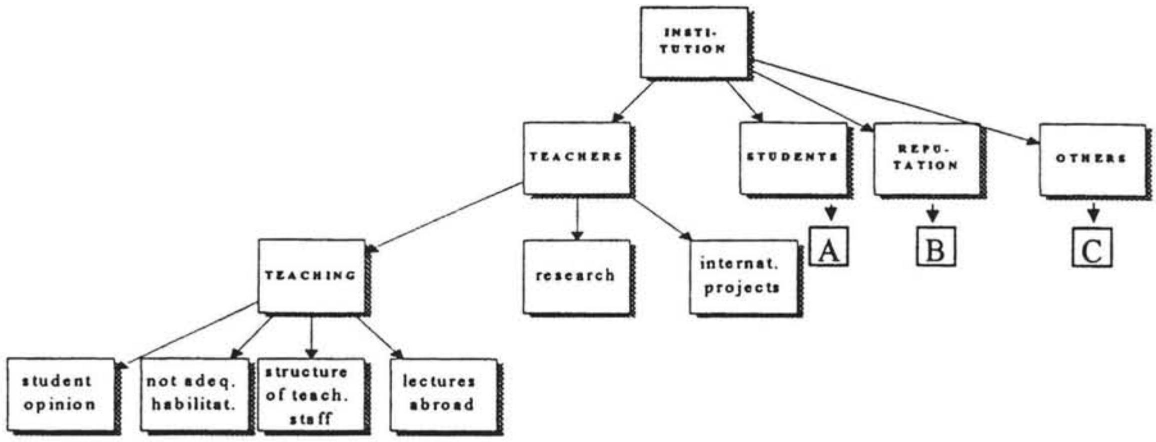

Fig. 2. A part of tree structure for the evaluation of higher education institutions

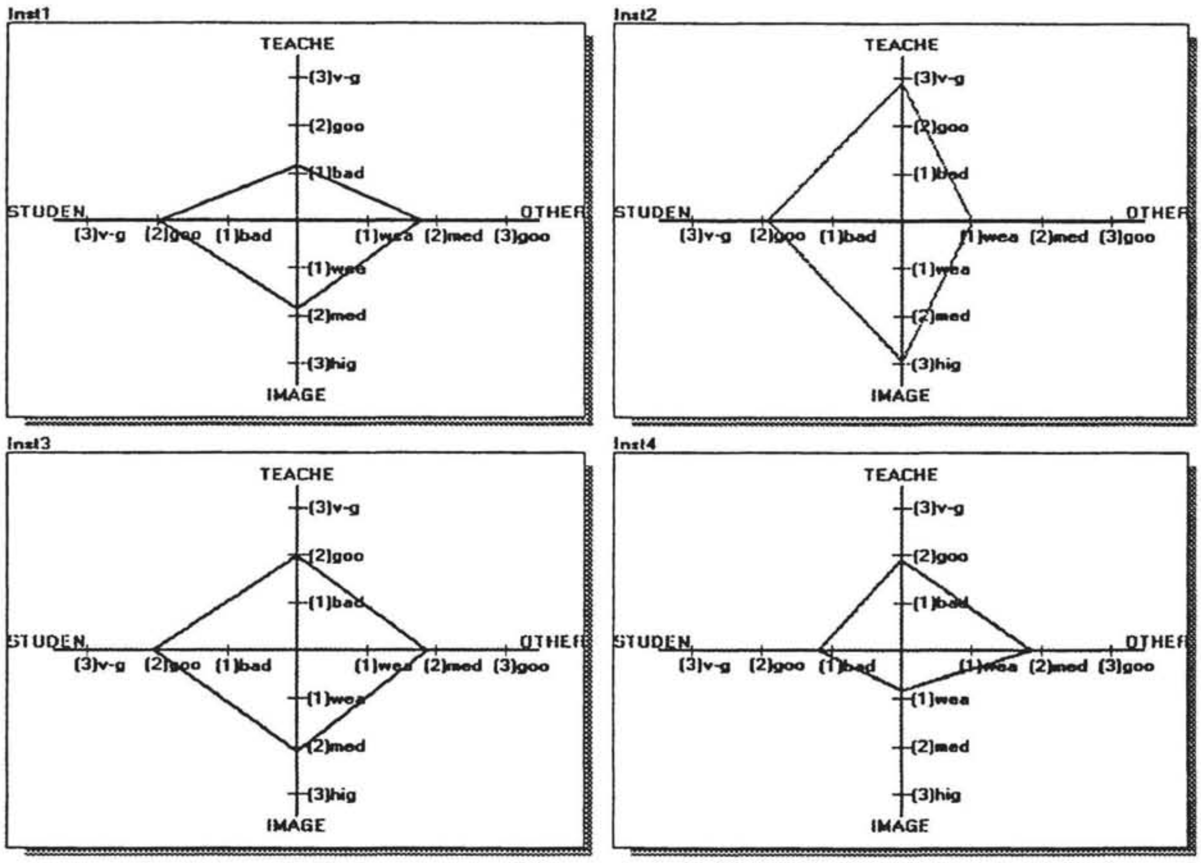

Fig. 3. Evaluation results

3. ANALYSIS AND EVALUATION OF INSTITUTIONS

Four higher education institutions were randomly selected, and data for the values of elementary attributes was provided. DEX evaluated these institutions according to the knowledge base and presented the results in a graphical and tabular form. A part of the graphical results is shown in Fig. 3. For institution 1 the overall result is "good", while for institution 2 it is "very good". The in-depth examination reveals that better values for "teachers" and the "reputation" of institution 2 contribute to its higher overall result. However, both institutions obtained the same value for students, regardless of low result for material conditions and costs for institution 2. In a similar way, institution 3 was evaluated as "good", and institution 4 as "weak".

These results can be further analysed by the group of experts. This enables the assessment of knowledge base performance and its improvement by changing the pool of attributes and adjusting the value scales of attributes. This procedure can be carried out several times in order to optimise the performance of the evaluation model. It is important that the expert group is aware all the time that they are building a system for objective evaluation, and they must avoid the temptation to tune it to some preferred solution.

At this stage of process, other attributes could be added which are either more difficult to define or which need more demanding preparation. In our case, one can add attributes such as reputation of institution from the viewpoint of stakeholders (i.e., companies where graduates are employed, how successful they are), comparison with foreign higher education institutions (e.g., study programmes, profiles of graduates), and recognition of diploma work and theses (e.g., nostrification of diploma work, M.Sc. and Ph.D. theses).

An important precondition for successful evaluation is the reliability of data from which the values for institutions are derived. A relatively small amount of data has been collected by administrative institutions, such as statistical bureau, ministries, etc. Most data are available only at higher education institutions. The reliability of data can be improved by more frequent data collecting, through better definition of data type, by insisting on citing names of data providers wherever appropriate, and by cross-checking of data.

The process of knowledge-base design with DEX is primarily suitable for the comparison of quality between institutions and not so much for the measurement of an absolute quality. Institutions are classified into classes which are defined by attribute values. They could serve as a starting point for strategic planning of institutional development. For example, the institutions that are ranked among the higher classes are expected to gain recognition and support for even quicker development while those in lower classes should be challenged to prepare special programmes for their improvement. Great support for this endeavour could be obtained if international criteria could be employed, but in most cases they do not exist, or else they cannot be directly adopted to the situation in a specific country.

4. CONCLUSIONS

The expert system tool DEX is designed to offer support in solving complex decision problems. The final interpretation of results should not rely only on the computerised system, but must also be made by human experts. In DEX, artificial intelligence and expert system elements are reflected in the knowledge base, which enables qualitative description of "soft" data. The knowledge base is developed by experts involved in quality evaluation. Clear presentation of parameters and their values enables ongoing verification of the evaluation procedure and appropriate adaptation of the knowledge base. This adaptation is usually obtained by expert consensus. The presentation of results is transparent, which enables a wide range of people to use and understand them. This property is specially important for the evaluation procedure, which involves conceptual approaches as well as quality attributes that quite often need dynamic modification. The usage of such a system therefore contributes towards the planning of higher education development.

5. REFERENCES

Berg, C. (1994). The international dimension of quality assurance - A strategy model. In: *Proceedings of the OECD Seminar I: Quality assurance and accreditation in higher education, Pilot project on regional co-operation in reforming higher education*, March 9-11, 1994, Ljubljana, pp. 5.

Bohanec, M. and V. Rajkovič (1990). DEX: An expert system shell for decision support, *Sistemica*, 1(1), pp. 145-158.

Brennan, J. (1994). Developments in quality assurance in the United Kingdom. In: *Proceedings of the OECD Seminar I: Quality assurance and accreditation in higher education, Pilot project on regional co-operation in reforming higher education*, March 9-11, 1994, Ljubljana, pp. 19-27.

Fernandez, M.T., A. Cabrero, M.A. Zulueta and I. Gomez (1993). Constructing a relational database for bibliometric analysis, *Research Evaluation*, 3(1), p.55-62.

Frazer, M.J. (1994). Self-evaluation and peer review in higher education, Presentation to the Council of Europe, Round table on higher education reform, Strasbourg, April 1994, pp. 5.

Irvine, J. (1989). Evaluation of scientific institutions: Lessons from a bibliometric study of UK technical universities, In: *Evaluation of scientific research*, Wiley, Chichester (Ciba Foundation Conference), p. 141-160.

Kells, H.R. (1993). The development of performance indicators for higher education - A compendium for twelve countries, OECD, CERI, Programme on Institutional Management in Higher Education, pp.147.

Kump, S. (1994). Assessment and assurance of higher education, *CRU News*, University of Ljubljana, 5-6, pp. 149 (in Slovene).

Rajkovič, V. and M. Bohanec (1990). Decision support by knowledge explanation. In: *Proceedings of the IFIP Conference on environments for supporting decision processes*, Budapest, June 18-21, 1990, pp. 41-53.

Zgaga, P. (1994). Concept of quality and higher education in Slovenia. International seminar on "Quality in higher education", Ljubljana, December 20-21, 1994, pp. 7.