Intelligent Curriculum Designer – Practical Implementation of Curricula for Engineering Courses

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Abstract: This paper presents an innovative methodology of designing curricula for engineering courses embodied in an artificial intelligence computer package named INCUDE, an acronym for Intelligent Curriculum Designer. It is a knowledge based system by which is possible to achieve a more effective and manageable course design and implementation. INCUDE comprises eight subdomains which are summarised in this paper. Not only does it improve the way of designing and implementing curricula but also it fosters an effective pedagogical approach - a current need in engineering education world-wide. INCUDE has already been successfully tested as a research tool and the principles behind the developed system have been implemented in United Kingdom and Brazilian Institutions.

Keywords: knowledge based system, engineering education, curriculum development

1. Introduction

The impact of information technology in engineering education has changed the way of designing curricula for engineering degree courses. Moreover, the engineers of the next century will face a challenging world which requires a fully prepared professional regarding knowledge, abilities and attitudes [1]. This has brought about an awareness of the need to improve curriculum design in engineering and its practical implementation plays a crucial role.

INCUDE is a knowledge based system for curriculum design that allows for local, national or international needs which may vary due to the different contexts. A major aspect of this work is that by applying knowledge based system technology to curriculum design and implementation it is assumed that important features of both curriculum development and knowledge based system are achieved.

The use of a knowledge based system allows the course designer to be educated in the philosophy underpinning the advice given and prepares them for future curriculum development and implementation exercises. This is particularly useful for engineering educators who have limited experience of curriculum development and may only have specialist subject content expertise [2].

2. INCUDE – Intelligent Curriculum Designer

INCUDE is a knowledge based system aimed at assisting users in designing an engineering degree course for any institution. It provides curriculum development concepts, principles and techniques rather than the subject content. The content is expected to be supplied by the user and the institution staff team after having undertaken one of the methods of curriculum content identification suggested by INCUDE.

The eventual outcome of running a consultation with INCUDE is a curriculum developed by the interaction of the knowledge and expertise embodied in INCUDE and the user input which takes account of the particular needs and context of the institution.

INCUDE interacts with the user by asking questions to the user who, by answering them, input institutional data. The advice given relies upon user answers and the expertise available in the knowledge base. The user will be able to get further details about the advice suggested if wished. A major feature of INCUDE is the Explanation Network [3]. The Explanation Network works in parallel with the main program as a system facility available for each question asked and advice given. As such, it consists of text frames with information, details and references about the relevant topic of the question and/or advice presented in the main program.

A knowledge based system is a branch of artificial intelligence which has been considered its most successful application [4]. The main parts of a KBS can be seen in Fig 1.

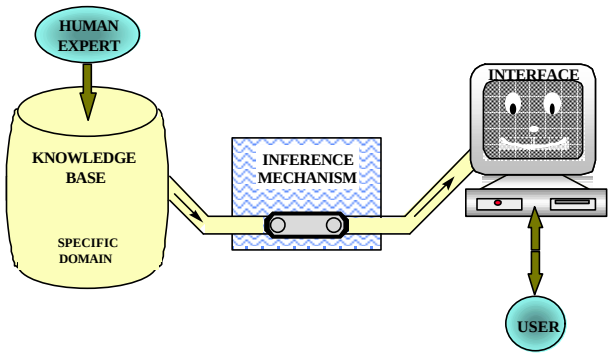

Fig. 1. Components of a Knowledge Based System

A knowledge based system ensures a flexible, user-friendly, low cost way of disseminating rare and costly expertise; favours the combination of expertise from more than one expert in the same knowledge base; takes account of users' particular context and suits their particular requirements by interacting with the users; organises the expertise by formalising and clarifying knowledge in a workable way which is represented through practical rules; makes more effective and efficient use of human experts; and develops user expertise.

INCUDE comprises eight subdomains which deal with "Introduction to Curriculum Development", "Methods of Course Content Identification", "Course Structure", "Learning Outcomes", "Teaching and Learning Strategies", "Student Assessment", "Course Documentation" and "Course Management". These eight subdomains are interconnected as shown in Fig. 2.

3. Curriculum Development

In order to help the user in designing a curriculum for an engineering degree course INCUDE adopts the Systematic Planning Approach [5]. It is a competence-based approach which concentrates first on aims and goals to be achieved and then selecting the means or procedures to realise them. This approach relies on the fact that a set of aims and related objectives can be stated, a set of methods to achieve these aims can be devised and techniques of assessment can be developed. In using this approach take into consideration the means available to implement the curriculum. Yet, do not let those limitations prevent the right decision from being made. Expedient Planning and Piecemeal Planning approaches are also available for consultation.

3.1 Introduction to Curriculum Development

Starting with this subdomain the user is advised on how to set about designing a new curriculum for an engineering degree course. It has been designed to make sure that crucial initial steps in the process of developing curriculum will be followed. It gives the user the chance to reflect upon the basic requirements that a successful curriculum should address. These include advice on time, budget and working-party who should carry out the method of identifying the Strengths, Weaknesses, Opportunities and Threats named SWOT Analysis [6].

In any case INCUDE assumes that: (a)evidence for starting the curriculum design process is clear; (b)the user have checked Institution/department resources; (c)planning permission has been given; (d)course designer have made an acceptable case for the course (rationale).

3.2 Methods of Course Content Identification

This subdomain assists the user in defining the most suitable method of identifying the curriculum content for an engineering course. The methods available are Introspection, Curriculum Enquiry, Dacum, Delphi and Task Analysis which are suggested depending on variables such time, budget, staff experience [7]. A complete profile of

the Staff Team is built at this stage and it is, on top of one condition needed for defining the method, a way of assessing staff expertise and consequently suggesting staff training procedure.

3.3 Course Structure

In order to have recognition (nationally and internationally) all courses need an acceptable structure. Course Structure is the framework which enables a certain body of knowledge to be imparted being designed to lead students to a particular qualification (award).

This particular subdomain deals with the Structure of the Course. It helps the user to define and design a structure which is suitable for institutional needs by advising on: (a) the concepts and principles which are relevant to this subdomain; (b) the requirements for applicants wishing to enter the course; (c) the number of years your course should have; (d) how students should progress throughout the course; (e) how to allocate time for teaching/learning activities; (f) the module specifications for each year - that is, number and size and (g) the integration of the content and timetabling.

3.4 Learning Outcomes

This particular subdomain deals with Learning Outcomes. It assists the user in writing and using the Learning Outcomes approach to curriculum development. Firstly the user is invited to learn the concepts and principles behind Learning Outcomes theory [8]. After that, a methodology for writing Learning Outcome Statements (LOSs) is developed. Finally the major goal of this subdomain is to enable the user to define a suitable number of Learning Outcome Statements for a given unit of the course and also assist the user in writing them. Learning Outcomes is a student centred and achievement led pedagogical approach very much required nowadays in engineering education.

3.5 Teaching and Learning Strategies

Effective teaching is a complex task, that demands intellectual competence and is socially challenging. It also contains a set of abilities that can be acquired, improved and extended. To teach efficiently, it is necessary to have a deep understand of the subject that this being taught, to consider what the students know, to understand how they learn and to know how to teach. It is necessary to be able to think and to solve problems, to analyze a topic, to decide which should is the appropriate approach, to select strategies and key materials, to organize and to structure ideas, information and tasks for the students. The subdomain Teaching and Learning Strategies focuses on these issues stressing two related topics: (a) Pedagogical Approaches and (b) Methods of Teaching and Learning

To achieve positive results in teaching activities, it is necessary to develop a method of teaching, or teaching/learning strategy, suitable to the context of the task. For this, it is suggested to examine five basic aspects which contribute to a teaching/learning strategy. They are: Materials and Teaching Resources; Educational Technology; Ability to Study; Teaching Techniques; Learning Activities. It is in the last activity that the effectiveness of the teaching and learning is achieved, by taking advantage of the other aspects listed.

3.6 Student Assessment

By combining a Bottom-up and Top-down approach in this subdomain INCUDE helps the user to design a Scheme of Assessment that suits engineering courses by presenting a methodology to approach this task and by giving specific advice on how to: (a)assess particular topics within a unit of study; (b)finalise a balanced assessment for the whole unit; (c)assess the implicit workload for students and teachers; (d)record the achievement of the students.

The organisation of the assessment for the course as a whole is developed in this subdomain as a Scheme of Assessment which comprises a group of Methods of Assessment which, in turn, is made up of some Components of Assessment. The user is advised to design a Scheme of Assessment which is appropriate and flexible. To be appropriate the assessment must match the relevant Learning Outcomes (or Objectives) and must demonstrate elements of Validity, Reliability and Efficiency. To be flexible the Method of Assessment, as far as possible, should be a mix of different Components of Assessment. Another consideration is the Formative and Summative

dimensions of the assessment [9]. It is suggested that all the Assessment Scheme should be designed as Formative even if due to the circumstances of course organisation or course management it turns out to be only Summative.

3.7 Course Documentation

This particular subdomain deals with the topic of Course Documentation. INCUDE defines Course Documentation as the framework of documents, which specifies the curriculum and contains the regulations and course management needed to keep a sufficient uniformity and quality in the course. It helps the user to write documentation that is suitable for institutional needs by advising on:

a) the concepts which are significant to this subdomain;
b) the selection of documents which are appropriate for institutional needs;
c) the choice of sections for each selected document;
d) how to write the chosen sections for each document;
e) how to recognise Course Documentation;
f) how to distribute Course Documentation;
g) how to maintain Course Documentation;
h) what is the cost estimated to produce and maintain Course Documentation;
i) the choice of a suitable author to write the documentation.

3.8 Course Management

This subdomain is not yet completed. However the subdomains created so far give sufficient help to enable the curriculum to be designed. Course Management will deal with two major issues, that is, Implementation Policy and Course Operation. The first one takes account of resources, legislation and organization, the latter defines course delivery.

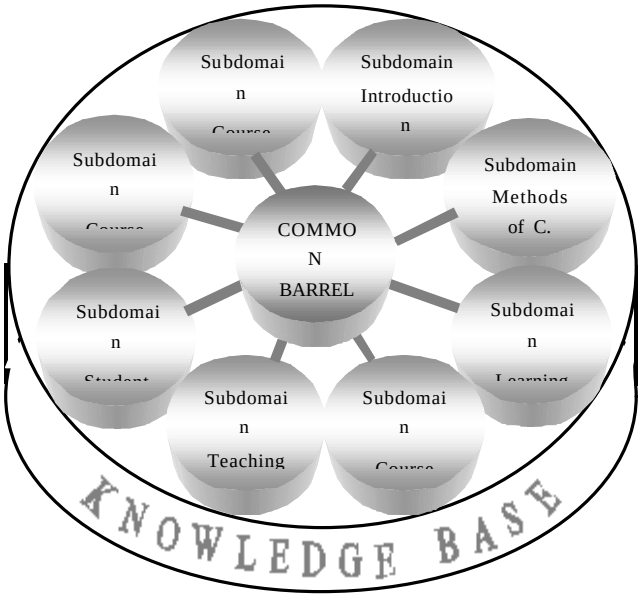

Fig. 2. Knowledge base for Curriculum Development

4. Results

The result of developing and implementing INCUDE is a knowledge based system whose domain is Curriculum Development divided into eight subdomains as seen in Fig. 2. It is a portable system implemented in a rule-based

expert system shell. The knowledge base embodies 600 rules, text frames and the Explanation Network written on 21200 lines of computer program. To be consulted, it requires a personal computer (PC IBM compatible) 486 onward machine, 8 Mbytes RAM, at least 2 Mbytes available on the hard disk (or disk drive) and printer.

INCUDE has demonstrated that techniques in knowledge based system methodology can be applied in a novel approach to Curriculum Development. Given that Curriculum Development is a major topic area in education theory and it has been, at best, a semi-quantitative subject, the pursuit of the first knowledge based system in this topic is a major innovation.

These results fulfils the aim of this paper by demonstrating that the overall domain of Curriculum Development has been delineated and this analysis has identified which subdomains are best for the application of knowledge based system techniques. Indeed, specific subdomains have been investigated in sufficient detail for them to be fully operative as individual entities. Furthermore, the techniques used have pushed the experts to release their underlying judgement and to verbalise knowledge as used in actual consultancy. This knowledge has been acquired together with the relevant explanations and both the rules and the explanations have been encapsulated into an expert system shell.

The integration of different subdomains has been ensured by both the methodology devised for developing INCUDE and the Explanation Network. This integration has guaranteed a smooth and appropriate overlapping between these subdomains. Knowledge refinement within these particular subdomains has reached a satisfactory conclusion from the point of view of the experts.

The user tests for individual prototypes and for the eventual knowledge based system have confirmed the usefulness and acceptability of this new approach to Curriculum Development. These tests have shown that the knowledge based system is a user-friendly and easy-to-use tool to assist in the design of curricula, thus being particularly suitable for the targeted audience in developing countries. In addition, the tutorial element in this knowledge based system has been welcomed by the users as an essential part of the system so that they can take full advantage of a consultation.

There has been a contribution to Curriculum Development theory, expanding its frontiers, by incorporating new knowledge - the expertise which was not considered publishable - that is, the quantitative rules in Curriculum Development. This contribution is therefore to be seen in the development of an approach which bridges the gap between formal theory in the area of Curriculum Development and the consultancy exercised by the experts as practitioners in this area.

5. Conclusion

The intention of this paper was to demonstrate that:

a) the methodology of knowledge based systems can be applied to Curriculum Development.
b) INCUDE can provide course designers with both:
    (i) a set of intelligent curriculum principles (which can be quickly accessed) and
    (ii) specific advice in their particular contexts which takes account of local needs and suits their specific requirements.
c) INCUDE has a very important potential application implemented as a tutorial package in the knowledge base to teach and train users in Curriculum Development principles and techniques named Explanation Network.

6. References

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