Scholars Journal of Economics, Business and Management OPEN ACCESS
Abbreviated Key Title: Sch J Econ Bus Manag
ISSN 2348-8875 (Print) | ISSN 2348-5302 (Online)
Journal homepage: https://saspublishers.com

A Rule-Based Expert System for Academic Advising and Guidance Toward Undergraduate Students

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DOI: 10.36347/sjebm.2024.v11i03.001 | **Received:** 01.02.2024 | **Accepted:** 07.03.2024 | **Published:** 23.03.2024

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Abstract **Original Research Article**

The provision of academic guidance to undergraduate students is a crucial and significant duty for the academic faculty in most prestigious universities. Expert systems are often regarded as one of the most successful areas in the field of artificial intelligence. The system utilizes a rule-based decision engine to assist individuals lacking experience in enhancing their skills. Nevertheless, a significant number of students are required to meet with their advisors to arrange their study schedule. This thesis is driven by the belief that the successful development of an academic advisory expert system will result in an expansion of the range and extent of challenges that students, academic staff, and other academic activities can effectively address, leading to a higher level of achievement in the university learning process. Nevertheless, the effectiveness of an advisory expert system is constrained by the caliber of the acquired knowledge, specifically in the context of academic advisory expert systems. The performance of such systems is primarily determined by the quality of the framework employed for academic expert knowledge acquisition. The objective of this study is to suggest a revision of the current knowledge acquisition framework in order to make it appropriate for implementation in higher education institutions. The proposed modification aims to create a prototype rule-based expert system specifically designed for academic advising of undergraduate students. The system's output also offers a precise and conflict-free course proposal for the undergraduate student. It functions as a mentor, providing undergraduate students with guidance and recommendations for suitable subjects based on their completed courses, prerequisites, and project scope, as defined by the student themselves. According to the empirical findings, the utilization of the proposed model for an undergraduate advisory expert system resulted in a noteworthy enhancement in performance.

Keywords: Rule-Based Expert System, Knowledge Acquisition, Knowledge Base.

1. INTRODUCTION

The increasing student population and expansion of academic programs within educational institutions have resulted in a significant accumulation of useful knowledge within these institutions. Consequently, there has arisen a necessity for the use of automated procedures that can effectively gather vast quantities of knowledge and facilitate the extension of the analytical process. The acquisition of information has been widely recognized as a crucial determinant of performance in educational institutions, including universities (Mohammad & Al Saiyd, 2010). Knowledge acquired refers to the knowledge obtained from professional specialists, which is subsequently documented in a primary source known as a knowledgebase. Inference methods, such as rule-based expert systems, can be utilized to obtain assessments and guidance details from acquired knowledge (Cernik, 2009; Al-Ghamdi *et al.*, 2012; McMahan & Bates, 2010; Patankar, 2006; Daramola *et al.*, 2014).

The field of artificial intelligence has made significant advancements in the domain of expert systems (ES). It is a decision engine that utilizes rules to assist non-expert users in enhancing their skills. According to Mohammad and Al Saiyd (2010), the ES is seen as a program that is developed by the acquisition of knowledge from specialists. The gained knowledge is stored in the knowledgebase by the expert system, which subsequently performs a series of procedures and preconditions to achieve optimal outcomes with the assistance of specialists (Daramola *et al.*, 2014). An expert system typically comprises the following components: According to Cernik (2009), Ahmar (2011), McMahan and Bates (2010), and Daramola *et al.*, (2014), the three key components of a system are the end user interface, the inference engine, and the knowledge base.

According to Mohammad and Al Saiyd (2010), there has been an increase in the number of firms that have transitioned their informational systems to adopt a rule-based expert system approach over the past decade. The observation necessitates the development of novel tools and settings that effectively transition established systems into contemporary, adaptable, and expandable knowledge-integrated systems (Kara & Karahoca, 2008).

1.1 RESEARCH MOTIVATION

Academic advice remains a persistent worry for students throughout their academic journey. The academic advisor's advising system is a crucial method for undergraduate students to mitigate the risk of making ill-advised decisions influenced by trends or peers. The aforementioned worry arises from a deficiency in promptly implementing system changes or strategic plans to effectively adapt to the rapid growth of the firm (Aldahadha & Al-Bahrani, 2012). According to Laff *et al.*, (1987), certain advisors lack the necessary expertise to effectively promote the integration of undergraduate students' learning progress (Aldahadha & Al-Bahrani, 2012, Pajewski, 2006).

The provision of academic advising to undergraduate students is a crucial and significant responsibility within the academic milieu of many prestigious universities. For instance, individuals are required to schedule visits with their advisers in order to strategize and organize their study calendar and timetable. The advising system plays a crucial role in helping students avoid making ill-advised decisions influenced by trends or their friends (McMahan & Bates, 2010; Choudhari, 2009). Moreover, the current advising system imposes a significant burden on academic advisors due to its time-consuming nature, resulting in a repetitive process where they are required to answer the same questions over. The institution may make modifications to prerequisites, processes, or curricula courses, and the advisers may be unaware of these changes. Additionally, it is worth noting that newly appointed faculty members may encounter challenges in the advising process due to their limited understanding of the academic and learning environments (Khali & Williamson, 2014; Aldahadha & Al-Bahrani, 2012; Mohammad & Al Saiyd, 2010).

The research outlined in this thesis is driven by the conviction that the successful development of an academic advisory expert system will result in a broader and more comprehensive range of challenges that students, academic staff, and other academic institutions can effectively address, thereby enhancing the overall quality of the university learning experience. Nevertheless, the effectiveness of an advisory expert system is constrained by the caliber of the acquired knowledge, specifically in the context of academic advisory expert systems. The performance of such systems is primarily determined by the quality of the framework employed for academic expert knowledge acquisition. Therefore, although the thesis presents a prototype for the rule-based system, the focal point lies in the development of an expert knowledge acquisition framework, also known as a model. Hence, the primary inquiry that the thesis tackles is:

- *What are the possibilities and capabilities to modify an existing knowledge acquisition framework to be more robust to use for Institutions in order to develop a rule-based system in an effective manner?*

1.2 RESEARCH OBJECTIVE

To answer this research question, this research is aims to:

- Suggest a revised iteration of the knowledge acquisition framework for implementation in the guidance of undergraduate students inside higher education institutions.
- Develop a prototype rule-based system for testing and evaluating the proposed knowledge acquisition framework.

1.3 RESEARCH LIMITATION

The proposed framework has been specifically developed to aid undergraduate students in higher education institutions in effectively managing their schedules by facilitating the selection of suitable subjects. It functions as a mentor, providing undergraduate students with a comprehensive plan that aligns with their completed courses.

1.4 RESEARCH CONTRIBUTIONS

The contributions of this research are two-fold. Firstly, this thesis proposed a new variation (modification) of the existing knowledge acquisition framework (Mohammad and Al Saiyd, 2010) to be more suitable and robust to use for higher education institute. Secondly, the thesis also developed a prototype rule-based system, based on the modified framework, for the academic advising of undergraduate students.

1.5 RESEARCH METHODOLOGY

The adopted methodology presented in this thesis is based on a spiral model (Boehm, 1988; Boehm, 2000) that works with iterations of the software development process. Our adopted methodology includes two main methodologies (i) Knowledge Engineering and (ii) Software Engineering, that are directed in iterations (i.e., overall life cycle of expert systems development) as shown in Figure 1.1. These two components are not sequential in nature, since some phases of the software engineering methodology may be applied before the completion of the knowledge engineering part and vice versa (Mohammad & Al Saiyd, 2010)

1.6 Knowledge Engineering Methodology

Transferring knowledge (i.e., experience) from an expert to the computer and this involves three activities:

- Knowledge acquisition,
- Knowledge analysis and modelling (knowledge representation), and
- Knowledge verification.

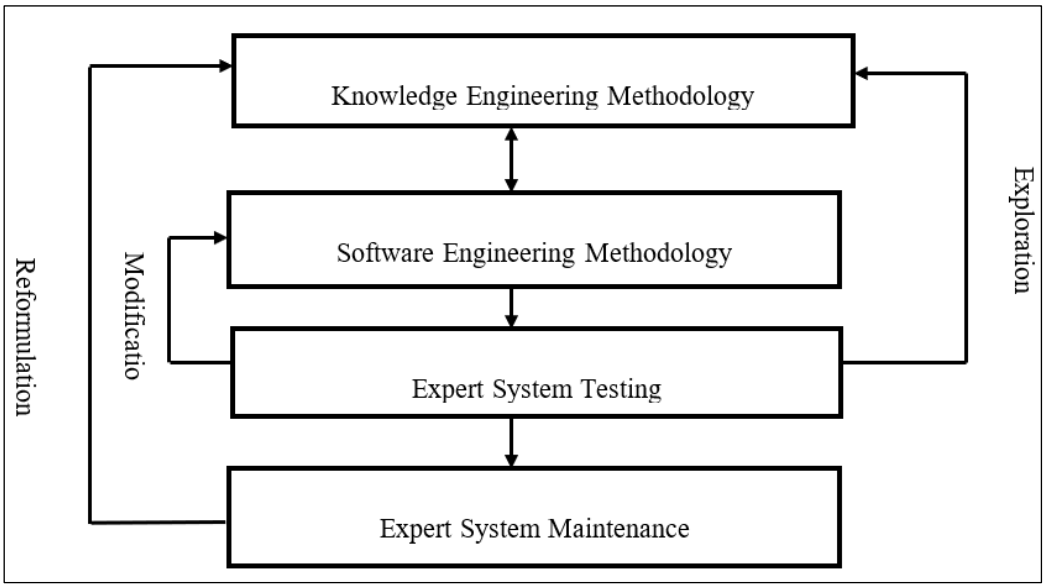

Figure1.1: Overall Life Cycle of Expert Systems Development Process

1.7 Software Engineering Methodology

As a system, developing a rule-based system entails doing software engineering activities that are accomplished in parallel with knowledge engineering activities that discussed above. These activities are:

- Requirements specification,
- Design,
  - Knowledge representation
  - Interfaces
  - Explanation module
- Implementation and testing.

1.8 Expert System Testing

Expert system testing the procedure which can be confident that the developed rule-based expert system satisfies all the determined requirements and the system performance in the right way. This procedure evolves through a cycle of three main steps, namely:

- Verification,
- Validation,
- Evaluation.

The details of the steps in implementation part (chapter four).

1.9 Expert System Maintenance

Expert system maintenance is one of the most important activities that apply a fundamental role in the methodology. There are mainly two objectives of system maintenance that are used in this thesis.

- Discover bugs, and problems that arise during the actual, at site running of the system and change from knowledge base and inference engine.
- Make sure that the system is up to date, by possessing the most accurate and the most recent knowledge concerning the domain of application.

1.10 CONCLUSION

In conclusion, the development of an academic advisory expert system presents a solution to the persistent challenges faced by students and academic staff in navigating the complexities of university education. This thesis has focused on addressing the need for a robust knowledge acquisition framework and the subsequent development of a prototype rule-based system tailored to the specific context of advising undergraduate students in higher education institutions.

The research began by identifying the deficiencies in existing advising systems, emphasizing the importance of promptly implementing strategic changes to adapt to the evolving educational landscape. Through the proposed knowledge acquisition framework, this research offers a structured approach to acquiring, analyzing, and modeling expert knowledge, laying the foundation for an effective advisory system. This framework, modified from existing models, ensures suitability and robustness for the targeted educational context.

Furthermore, the development of the prototype rule-based system demonstrates the practical application of the modified framework. By integrating knowledge engineering and software engineering methodologies in a spiral model, the research outlines a systematic approach to system development, ensuring iterative refinement and validation.

The testing and evaluation of the expert system underscore the importance of verification, validation, and ongoing maintenance in ensuring system reliability and relevance. Through these processes, the system can evolve to accommodate changing requirements and incorporate the most up-to-date knowledge, thereby enhancing its effectiveness in supporting student academic success.

Overall, this research contributes to the advancement of academic advisory systems by providing a comprehensive framework and a practical implementation tailored to the needs of undergraduate students in higher education institutions. By bridging the gap between expert knowledge and student guidance, the proposed system has the potential to significantly improve the quality of the university learning experience, empowering students to make informed decisions and optimizing the role of academic advisors in supporting their academic journey.

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