Framework for Academic Advice through Mobile Applications

Olaperi Yeside Sowunmi *olaperi.sowunmi@covenantuniversity.edu.ng*
Department of Computer and Information Sciences, Covenant University, Ota, Ogun State, 112212, Nigeria

Sanjay Misra *sanjay.misra@covenantuniversity.edu.ng*
Department of Computer and Information Sciences, Covenant University, Ota, Ogun State, 112212, Nigeria

Luis Fernandez-Sanz *luis.fernandezs@uah.es*
Computer Science Department. School of Engineering, University of Alcala, University Campus Alcalá de Henares, Spain

Jose-Amelio Medina-Merodio *josea.medina@uah.es*
Computer Science Department. School of Engineering, University of Alcala, University Campus Alcalá de Henares, Spain

Abstract

The increasing rate of high (secondary) school leavers choosing academic majors to study at the university without proper guidance has most times left students with unfavorable consequences including low grades, extra year(s), the need to switch programs and ultimately having to withdraw from the university. In a bid to proffer a solution to the issue, this research aims to build an expert system that recommends university or academic majors to high school students in developing countries where there is a dearth of human career counselors. This is to reduce the adverse effects caused as a result of wrong choices made by students. A mobile rule-based expert system supported with ontology was developed for easy accessibility by the students.
Keywords: Mobile Expert System; Academic Major; Career choice; Ontology; Rule-Based Expert System; Career Counseling

1. Introduction

The choice of a career needs to be made with great care, following established principles [6] because; a wrong decision has adverse effects both within the academic institution (bad academic performance, academic frauds, the need to change majors) and in the society (job dissatisfaction, low productivity, regret, social ills) [39].

Traditionally, career counselors are saddled with the responsibility of guiding students; they help students individually by analyzing their answers to questions which tests for particular capabilities, potentials, interests and personalities of the students. The process nonetheless is quite rigorous, demanding a lot of effort and time. This makes it arduous to carry out a very thorough analysis for a large number of students. Moreover, in most secondary schools today in Africa, career counselors are either inadequate or unavailable, as such students do not have adequate access to counseling services [29, 28, 3]; they therefore make career choices without experts' advice giving no consideration to the necessary factors. Their judgments are usually frivolous, dittoing their friends or following the popularity and seeming prestige an academic major accords. They are also often unaware of all the available career options - especially contemporary ones [28,27,33].

Expert systems however, can be developed to incorporate knowledge and make decisions that would otherwise require human experts. They are systems capable of imitating the intelligence of human experts in specific domains to assist the humans or serve as a substitute where they are unavailable. They have been applied in areas such as medicine for diagnosis and prescription [4]; accounting for financial forecasting and portfolio management [41]; engineering [22], and education [13].

To enhance the accessibility of these systems, they can be hosted on the internet and developed in a suitable way for mobile devices. Technological advancement in device miniaturization and wireless computing technology has led to the development of small and portable powerful mobile devices [12] such as smartphones, PDAs, tablets and laptops which are ubiquitous today. These devices though often of a lower processing power, are Internet-enabled and can easily access expert systems uploaded on a webserver anywhere and anytime in a very convenient and usable manner.

This work therefore provides a mobile-based career advisory expert system to be used by high school students and other individuals to choose an academic major. The system built is a rule-based expert system enhanced with ontology to improve its robustness. The mobile accessibility of the system was developed using the responsive web design technique [31]. Knowledge from expert career counselors was captured via interviews and a thorough document analysis and represented using production rules. The Java Expert System Shell was used as the inference engine.

The remainder of this work is organized as follows: Section 2 reviews relevant literature and related works. Section 3 describes the methodology and Section 4 shows the design of the system. Section 5 illustrates the implementation of the expert system and discusses its evaluation while Section 6 presents the conclusion and future works.

2. Literature Review

The main elements of this research: career choice, mobile systems, and rule-based expert systems are discussed in this section using relevant literatures. Previous related studies are also reviewed.

2.1. Career choice and counseling

The choice of a career is one of the most important decisions one would make in life, however, the options available to choose from are restricted by the choice of an academic major that must have been made earlier in life. It is a decision that rubs on other aspects of life and has long term effects. It is referred to as one of the most difficult decisions [27] therefore, should be made thoughtfully and decisively, rather than left to chance. A wrong choice of career or major can make even the brightest of students to perform below expectation. However, when the appropriate career choice is made, one is better positioned to earn good grades, stick with the choice through graduation, graduate on time, and derive long term satisfaction [20]. Career counseling is thus fundamental to students' success because it helps them discover their potentials and acquire the needed knowledge for building a fulfilling lifelong profession [29].

2.2. Mobile Systems

Mobile computing systems are computing systems that are moveable i.e. their computing capabilities can be used during movement [7]. According to [12] 'mobile computing is concerned with exploiting the connectedness of devices that move around in everyday world'. Mobile computing has been made possible due to advancement in device miniaturization and wireless technology which has led to the portability and interconnectedness of devices. Mobile applications are basically applications or software packages that run on mobile devices. With the proliferation of the market by mobile devices, mobile applications are also on the increase. Statistics have shown that the Internet is now being accessed more from mobile devices than the regular PC computers [23]. This implies that applications that aim for a wide coverage should consider easy and usable mobile interfaces.

Different platforms exist for mobile application development. They include: Palm OS, Symbian OS, Windows Mobile and Blackberry OS. The latest and leading ones today are: Google's Android, Apple's iOS, and Microsoft's Windows Phone. Custom apps can be built individually for each of these platforms; however, it usually involves high cost and maintenance. Mobile websites are another option; they are websites built specifically for mobile devices [26] and accessed via mobile browsers. One major advantage is that they help to provide a solution to the market fragmentation caused by the availability of different mobile platforms because they can run on all these different platforms. Mobile web apps offer cross-platform, scalable and affordable, quick time-to-market development solutions. They are usually found on a 'm.' or 'mobile.' subdomain [10]. However, for best user experience, they still need to be customized for each device. With the upsurge in the variety of mobile devices and platforms, it is becoming increasingly difficult and expensive to develop and maintain different apps and websites, (both desktop and mobile) that will suit each user experience on all platforms. This led to the innovation of the responsive website design.

2.3. Related works

Expert systems are a branch of applied Artificial Intelligence developed in the mid-1960s [21]. Expert systems often imitate the problem solving skills of experts to aid complex decision making [41].

Hooper et al. [19] already addressed in 1998 the application of expert systems to personnel selection process in the army. However, our review will start with MyMajors [40], an Internet-based expert system that offers advice to high school students and college freshmen. The advisor uses information about the students: grades, enjoyed course, standardized test scores, interests and aptitudes to assess their suitability for a major. At the end of the evaluation, the expert system recommends six majors. While the application developed is internet based, it does not provide further explanation to the students on the choice suggested, it also requires some examination scores which are not generic and applicable in all context.

Abu Naser, Baraka, and Baraka [1] proposed an expert system for guiding freshmen students in Al-Azhar University. Knowledge for the expert system was acquired from human academic experts and online resources (website) and the CLIPS expert system shell was used as the knowledge base and inference engine. Microsoft Visual Basic was used to build the GUI to make communication with the students easier, hiding the CLIPS command line interface. The expert system acquires student's general background information and measures their abilities via some standardized questions.

Winston and M. Lawrence, [40] developed a model that uses personality analysis, job suitability and college entrance criteria to offer career guidance to prospective candidates.

Deorah, Sridharan, and Goel, [14] modeled an expert system - SAES for advising academic major. SAES was developed to provide Indian students with intelligent advice regarding the academic major to choose by inquiring of the student's academic performance, implicit and explicit interests. Knowledge was acquired from candidates via questionnaires and the first order language was used to formalize the knowledge after which SAES used the rule-based mechanism to generate inferences.

Ayman Al Ahmar, [5] developed a major-selection rule-based expert system with object oriented modeling techniques to guide high school students to select appropriate university majors. The system was built with an object-oriented database, and a GUI for user interactions. The system was implemented using two (2) sets of rules: the university's admission requirements and the students' preference cum skills.

Bouaiachi, Khaldi, and Azmani [9], developed an expert system called SAGES-Student Advisory and Guidance Expert System to reduce the time and effort expended by the human counselors. The system was developed using an object oriented database structure and rule based reasoning with the help of the Kappa-PC expert system. The expert system assists students in selecting a major and suggests one or more institutions of learning based on the student's academic criteria, current degree, degree classification, available majors and institution.

All these systems, [22, 40,-26] are desktop based, that is standalone systems, and they were all designed for specific universities except for [40] which was a general concept for a country and [24] for which it was not specified.

Borges, et al. [8] showed a domain ontological model is presented as support to the student's decision making for opportunities of University studies level of the Venezuelan education system.

In summary, the following gaps were identified: Limited accessibility of existing systems due to desktop/standalone implementation, except MyMajors [40], language barriers [1,9], restrictions to specific universities or faculty [1, 14, 5, 9], unavailability of an explanation facility, a limited number of majors and unsuitability for the every context based on some test scores required for the prediction. Therefore, this work is aimed at developing an expert system that would be readily available on mobile platforms providing a sufficient explanation facility, and linking recommended majors to other related majors, by building a simple ontology [15] in order to increase the number of majors available for the students to choose from.

3. Research Methodology

For the realization of this article, the authors have followed the methodology proposed by Peffers, et al. 2007 [30]. First, we analysed the problem identified and from the motivation, we defined the objectives to achieve. We then designed and developed an artefact to reach and check our objectives.

In the next phase, we demonstrated the resulting process model through experimentation, simulation, and case study. After which we evaluated the process model using user's satisfaction surveys and user's feedback. Finally, we have shown our result in subsequent sections in this paper.

4. Design approach

The steps for this research include: Knowledge Acquisition and Requirement Specification, Knowledge Representation, System Design, Implementation and System Evaluation [24]. These steps are shown in Figure 1 and described in this section.

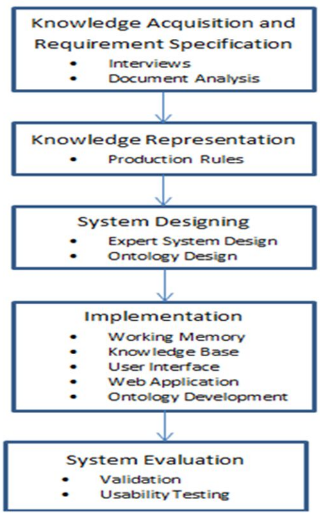


Fig. 1. Steps to Research

4.1 Knowledge acquisition/ requirement specification

The first step in building an expert system according to [24] is knowledge acquisition. The requirements and knowledge for the expert system were acquired via semi-structured interviews and document analysis. According to [38] an interview is a manual knowledge elicitation technique that involves direct conversation between the domain expert and knowledge engineer and it is a valid method of data collection. Domain experts, high school counsellors were identified and interviewed. The experts were asked to give a walk-through of how they would guide a student in the choice of a major, and the thought process as described was captured. The general expectations of such system were also discussed.

First, the student is asked different standardized questions to assess his/her personality type, and interests. These questions also help to show the student's capability and aptitude. The expert then applies the specified weight to each question, and carries out a calculation of the student's dominant personality type. After this, the student is tested on a set of majors pertaining to his/her dominant personality to check for the most suitable ones.

Sequel to this, a thorough document analysis was carried out, and several standardized questions were identified and an occupation-major mapping was carried out to extract the personality types of the majors offered in Nigerian Universities. Other relevant and needed information were also extracted from reliable sources and verified by the expert. The knowledge acquisition process continued through the project life-cycle as the system was built iteratively with constant interaction with the domain expert.

4.2. Knowledge representation

After the knowledge acquisition, the knowledge gathered was properly analysed and represented in a symbolic way using production rules. These rules are expressed in English form below. The Jess rule language was used to represent them in the expert system shell as shown in section Expert System Design

```
(1)  IF Student's_Highest_Score IS IN Personality_X
     THEN Personality_X IS  Student_Dominant_Personality
```

4.3. System design

This section explains the conceptual framework of the system, the expert system development and the ontology design. It also discusses the implementation and the tools that were used.

4.3.1 System architecture

The architecture for the entire system is shown in Figure 2.

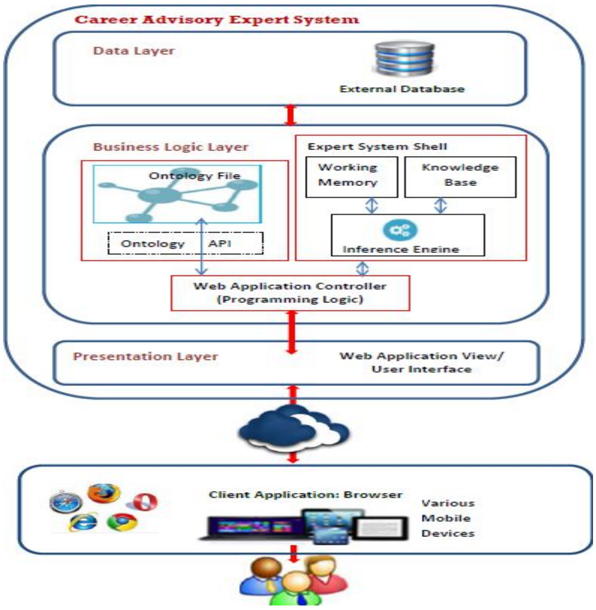


Fig. 2. System Architecture.

The system design stage comprises of two design sub-components, the expert system design and the ontology design.

The system built was based on three-tier architecture: the Presentation Layer, the Middle/Business Logic Layer and the Data Layer. The presentation layer is where the user interacts with from any mobile device. This is where the client application runs. The client application is a thin client, because it basically presents information to the user, captures the user's response and forwards it to the business logic layer. The middle/business logic layer carries out the system's functionality. It contains all the web application code including the programming logic and the Jess facts and rules. It also contains the Java Expert System Shell that executes the rules using the forward chaining inference mechanism, the rules file that is loaded at application start up, and the ontology file. The data layer stores the knowledge base and other data needed by the application. The three-tier approach used ensures separation of concerns, which makes future maintenance and scaling-up of the system easy.

4.3.2. Expert system design

According to [24] and [17], the major components of an expert system are the user interface, the inference engine, the short-term/working memory and the knowledgebase/long term memory.

The working memory which is also known as the fact-base contains all the information that JESS, the expert system shell works with. It contains the data that the rules act on. These working memory elements are called facts. In building the working memory, six different sets of facts were used, and they were defined with the deftemplate Jess construct.

After the structure of the facts were specified by the deftemplate, individual facts were populated into the working memory using the deffacts and the assert Jess constructs using the Java programming language. The data used was both from the database (for fixed data like academic majors), and from the user (based on their answers to the questions).

4.3.3. Building the knowledge base

The expert system built is a rule-based system, because, the knowledge of the experts in this domain used in solving the problem can be suitable expressed in the form of rules. The knowledge base is the component of the expert system that contains the set of rules that make up the rule based system. The rules used in constructing the expert system are made in the Jess rule language and an example is shown below. They are all forward chaining rules. They are pattern matching rules, not fixed rules - templates that can be used with changing variables.

```
Rule 1- Matching student's main personality to corresponding majors I
(defrule personality-match-one "matching users main personality with majors
main personality"
(user (uname ?uname) (personality-one ?pone))
(major (major-name ?majname) (personality-one ?pone))
 =>
(assert (recommendable (user ?uname) (major-name ?majname)))
```

4.4. The Inference Engine

The inference engine used is the JESS-Java Expert System Shell, which implements an advanced version of the Rete Algorithm. It applies the rules to the content of the working memory.

4.4.1. The User Inference

The responsive web design was used to build the user interface. This was implemented using HTML5 and CSS3. The user interface adapts itself to the view port of the device used to access it, regardless of whether it is a desktop, smartphone or tablet.

4.4.2. Ontology design and development

Ontology was designed to model academic majors and their relationships. It was designed with the Web Ontology Language, using the Protégé ontology editor. The main class was 'Academic Major' which has 59 subclasses representing the 59 main majors recommendable by the system. Each of these 59 majors, have respective subclasses, a total of 31, which represent majors that are similar, and that require the same individual personality and attributes. This makes the total number of academic majors recommendable by the system sum up to 90.

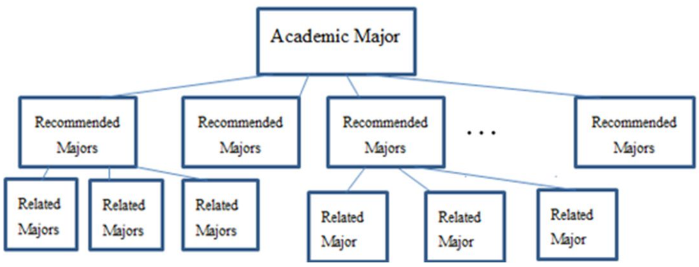


Fig. 3. Schematic View of the ontology.

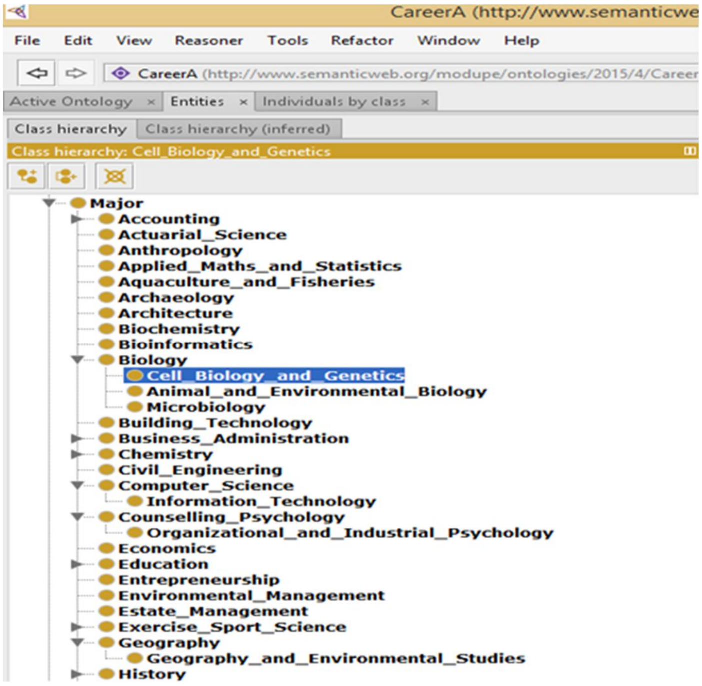


Fig. 4. Ontology Development.

When a major is recommended, the system also shows the related majors and this makes this the overall system more robust, eliminating the limitation of a restricted number of majors. The Apache Jena API version 2.13 was used to interact with the ontology built. A schematic view of the ontology designed is shown in Figure 3 while the class hierarchy of the developed ontology is depicted in Figure 4.

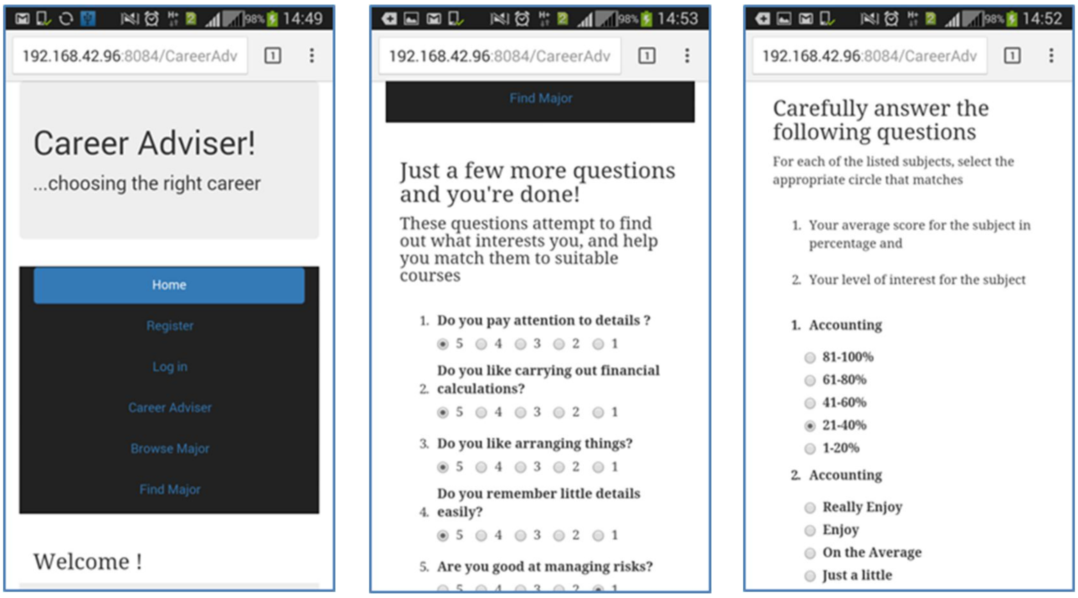
5. Implementation

The implementation tools and development environments used are discussed next.

To develop the core system, the server-side and dynamic nature of the application, Java programming language was used, together with Servlets and JSPs – Java Server Pages. HTML5 and CSS3, leveraging on the Bootstrap framework were used to implement the responsive web design nature of the application's interface. The Apache Tomcat web server was used to host the application, because it provides implementation for servlets and JSPs. The Java Expert System Shell (JESS) was used for the inference engine of the expert system. It supports rule-based reasoning and forward inference mechanism which were appropriate for the developed system. Jess efficiently implements an enhanced version of the Rete algorithm which makes it very fast. It was also used because it can be directly integrated with the Java programming language and other Java technologies.

Once the application is launched, the welcome page is displayed together with instructions to be followed. The user is taken through series of questions from page to page that evaluate different characteristics of the user. After all the questions have been successfully answered and submitted, the inference engine is executed, the facts are asserted and appropriate rules fired and the consequent portion of the fired rules are executed. At the end of the process, the suitable academic majors are presented. Based on the recommendations, the ontology file is queried to also extract related majors. All these majors, together with an explanation are then presented to the student. The student can also browse the recommended majors for more information on them. The responsive web design incorporated makes the application run suitably on any device accessing it.

The expert system as it runs on a smart phone is depicted in Figure 5.



(a) Home Screen (b) Interests Test (c) Subject-based Test

Fig. 5. Main application screen.

5.1. Evaluation and validation of the system

The developed system was validated and tested. Face validation was conducted by a domain expert to authenticate the recommendations of the system while usability testing was done to determine its ease of use. A table of comparison with other systems previously reviewed is also presented. Details are presented in this section.

5.1.1 Expert System validation

Validation is the process of analyzing the knowledge and decision-making capabilities of the expert system i.e. its accuracy and completeness [35]. Face validation which was discussed by different authors was used [35, 37]. It involves asking an expert to assess the internal behavior and generated output of the system. According to [35] it is a preliminary approach to validating which carries out a cursory appraisal of the expert system's performance. This was thoroughly carried out by one of the domain experts consulted. The questions and their corresponding mapping, as well as the outcome of the system was studied and verified during the usability testing with 21 (twenty-one) high school students. The students used the expert system, and the expert also accessed the students, and the outcome of the expert system was weighed. The outcome of the expert system was validated and slight adjustments recommended have been incorporated into the system.

5.1.2 Usability testing

Usability is one of the emergent properties and software quality measures of a system which measures a system as a whole, rather than its component parts. It reflects how easy to use a system is [36]. According to [32], usability testing is an attempt to quantify user-friendliness of a system, while measuring the skill and time required for using the system efficiently. It is a subjective assessment of user's attitude to a system, one of the ways it is measured is via a questionnaire [36, 32]. The questionnaire was built based on eight (8) usability factors identified in [2]: Simplicity, Navigation, Memorability, Hypertext-structure, Satisfaction, Consistency, Completeness and Self-evidence.

The questionnaire was divided into two sections; the first section was to extract background information of the users and their level of interaction with mobile devices while the second focused on questions to assess the usability factors. The questionnaire was designed using a five-point Likert scale, with '5' meaning Strongly Agree and '1' meaning Strongly Disagree. The respondents were students from a high school in Ota, Nigeria. They interacted with the expert system using a laptop and an android smart phone. A total of 21 students evaluated the study, and this surpasses the 20 respondents prescribed by [16]. The students were not trained prior to using the system because it's to be used with little or no guidance by different users that are widely geographically dispersed.

5.1.3 Result Analysis

In the first section of the questionnaire, only 20 responses were valid. Based on their skill and level of interaction with mobile devices, the results showed that 15% were novice users, 30% were average users, 25% were good users, and 30% expert users. 70% reported that they interact with a mobile device on a daily basis, 20% on a weekly basis, and 10% on a monthly basis. 66.6% accessed the expert system via a laptop while 33.3% accessed it via an android smart phone. Only one respondent reported no access to a mobile or Internet-enabled device. An overall score was computed for each of the usability factors measured using the mean of the user ratings. According to [25] as cited in [34] a mean rating of 4 on a 1-5 scale rating suggests good usability.

6. Comparison with related Works

The system developed was compared with the related works reviewed. Of the six previous studies reviewed, only [18] incorporated mobile accessibility to an extent; however, the system developed was not built specifically for easy accessibility of varied mobile devices. The studies also did not report an explanation facility. MESAA on the other hand was built with the responsive web design for accessibility by any mobile device, it also incorporates ontology for robustness to increase the number of academic majors recommended. Explanations are also given to the student. The system was implemented in English. MESAA has a total 90 recommendable majors, 59 derived from the expert system shell, that is from the pre-specified rules, and 31 related majors from the ontology

7. Conclusion and Future Works

This research culminated in building a mobile-based expert system (MESAA) for career advice after adequate requirements elicitation and knowledge acquisition from domain experts and relevant reference materials. A rule-based expert system was built based on a three-tier architecture. The three tiers represent the data layer, middle/business logic layer and the presentation layer. The data layer contains the data that is used by different components of the system, such as the working memory and the rules used by the inference engine; the questions used in the presentation layer to extract useful information from the students and other data that needed to be stored. In the middle layer lie the functional components of the system including the expert system shell, and the web application logic. The presentation layer comprises of the interfaces that the users interact with.

The proposed system that was developed is to be used by graduating high school students in the choice of an academic major before requesting admission in universities. The expert system implements rule-based reasoning, and is complemented by an ontology, which to make the advice given more robust. The system is to reduce the wrong choices being made by students which can have negative effects on them and the society, it provides a career adviser for students who do not have access to one and reduce the work load on available career counselors. It is generic, as it does not require test scores specific to certain countries, which makes it directly applicable to students in developing countries. It also provides explanation to the student, which strengthens the student's understanding of why the choice was advised.

The system has been validated by an expert career officer and tested by high school students. The usability evaluation conducted to test the ease of use of the system by the intended users – high school students reveal that the system is highly usable.

The limitations of this work are in its testing and validation. The system was tested by about 20 students who are the potential students, while this number is sufficient for a usability test, it does not really reflect an adequate percentage of the total number of potential users. Moreover, the final system was validated by one domain expert, notwithstanding, the recommendations were highly correlated.

This research presents a new case study to validate the suitability of intelligent systems, specifically expert systems to solve advisory problems, particularly in education. It also further validates that with ontologies, expert systems can be made to be more robust. This system does not eradicate the need for career counselors; however, it helps in a crucial role they perform which is of utmost benefit to students.

For future research, the system can be upgraded to recommend universities for the students based on their specified preference on certain criteria. The ontology used in the system can be expanded to make the recommendations of the expert system more robust. Moreover, the system can be built specifically to handle junior high school and senior high school students separately, while also including functionalities for individuals who are already through with university and college and want to make more specific career and job decisions.

The eSkills Match project where the University of Alcalá is currently involved is aimed at offering a system for assisting potential candidates to self-assess themselves according to a model based in the standard EN 16426 (so called eCF, eCompetence Framework). The system will act as a recommender system (like other similar in the area of competences, e.g. [11]) suggesting for developing the competences and skills needed to match the target professional profile. The work with the expert system presented in this paper was also designed as a development of supporting underlying technology to be incorporated in the future system of the eSkills Match project.

Acknowledgements

This work has been partially funded by European Commission through the project e-Skills Match under the grant agreement no. ECOKT2014-7 (30-CE-0726730/00-60).

References

1. Abu Naser, S.S. Baraka, M.H. and Baraka, A., 2008. A Proposed Expert System for Guiding Freshman Students in Selecting a Major in Al-Azhar University, Gaza, Journal of Theoretical and Applied Information Technology, 889-893.
2. Adewumi, A.O., 2012.Deployment and Usability Evaluation of Mobile Access to Institutional Repository.
3. Anasi, S.N.I., 2010. Curbing Youth Restiveness in Nigeria: The Role of Information and Libraries, Library Philosophy and Practice , 1-7.
4. Arsene, O. Dumitrache, I. and Mihu, I., Expert system for medicine diagnosis using software agents, Expert Systems with Applications, (2015), 1825-1834.
5. Ayman Al Ahmar, M., 2012. A Prototype Rule-based Expert System with an Object-Oriented Database for University Undergraduate Major Selection, International Journal of Applied Information Systems (IJAIS), 38-42.
6. Baloch, R.A.S. and Shah, N., 2014. The Significance of Awareness About Selection and Recruitment Processes in Students' Career Decision Making, European Scientific Journal, 536-552.

7. B'Far, R. 2004, Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML. New York, Cambridge University Press.
8. Borges, A., et al. "Ontological Model as Support Decision Making in Study Opportunities: Towards a Recommendation System." 4th WSEAS/IASME International Conference on Educational Technologies (EDUTE'08). 2008.
9. Bouaiachi, Y. Khaldi, M. and Azmani, A., 2014. A Prototype Expert System for Academic Orientation and Student Major Selection, International Journal of Scientific & Engineering Research, 25-28.
10. Castledine, E. Eftos, M. and Wheeler, M. 2011, Build Mobile Websites and Apps for Smart Devices, SitePoint.
11. Chavarriaga, A., Florian-Gaviria, B., Solarte, O., 2014. A Recommender System for Students Based on Social Knowledge and Assessment Data of Competences, *Open Learning and Teaching in Educational Communities* ,Vol. 8719, Lecture Notes in Computer Science pp 56-69
12. Coulouris, G. Dollimore, J. Kindberg, T. and Blair, G., 2012. Distributed Systems, Addison Wesley.
13. Daramola, O. Emebo, O. Afolabi, I. and Ayo, C., 2014. Implementation of an Intelligent Course Advisory Expert System, (IJARAI) International Journal of Advanced Research in Artificial Intelligence, 6-12.
14. Deorah, S. Sridharan, S. and Goel, S., 2010. SAES- Expert System for Advising Academic Major:An Indian Perspective, in 2010 IEEE 2nd International Advance Computing Conference, 331-336.
15. El Haji, E. Azmani, A. and El Harzli, M. (2014) Multi-expert system design for educational and career guidance: an approach based on a multi-agent system and ontology. International Journal of Computer Science Issues (IJCSI) 46-52.
16. Faulkner, L. 2003. Beyond the five-user assumption: Benefits of increased sample sizes in usability testing, Behavior Research Methods, Instruments, & Computers, 379-383.
17. Friedman-Hill, E., 2003. Jess in Action: Rule-Based Systems in Java. Grrenwich, Manning Publications Co.
18. Grupe, F.H., 2002. An Internet-based expert system for selecting an academic major: www.MyMajors.com, Internet and Higher Education, 333-344.
19. Hooper, R.S. Galvin, T.P. Kilmer R.A. and Liebowitz J., 1998. Use of an expert system in a personnel selection process. Expert systems with Applications 14 425-432.
20. Jones, L.K., 2014. Career Key. [Online]. http://www.careerkey.org/pdf/choosing-a-major-with-personality-match.pdf
21. Liao, S-H., 2005. Expert system methodologies and applications—a decade review from 1995 to 2004," Expert Systems with Applications, 93-103.
22. Lin, S-S. Horng, S-C. and Lin, C-H., 2009. A Neural Network theory based expert system – ICRT, Expert Systems with Applications, 5240–5247.
23. Mobile marketing analytics. 2016. http://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics, Accessed june 22, 2016
24. Negnevitsky, M., 2005. Artificial Intelligence: A guide to intelligent systems. England: Pearson Education.
25. Nielsen, J. and Levy, J. (1994) Measuring usability: preference vs. performance, Communications of the ACM, 66-75.
26. Oehlman D. and Blanc, S. 2011, Pro Android Web Apps: Develop for Android using HTML5, CSS3 & JavaScript, Apress.
27. Oluwatimilehin J. B. and Owoyele, J.W., 2009. Career Aspirations: An Investigation of Senior Secondary School Students Awareness of Contemporary High Profile Careers., European Scientific Journal, 87-97.
28. Onoyase D. and Onoyase, A., 2009. The Relationship between Personality Types and Career Choice of Secondary School Students in Federal Government Colleges in Nigeria, Anthropologist, 109-115.

29. Oye, N.D., Obi, M.C., Mohd, T.N. and Bernice, A. (2012). Guidance and Counseling in Nigerian Secondary Schools: The Role of ICT, International Journal of Modern Education and Computer Science (IJMECS), 26-33.
30. Peffers, K., T. Tuunanen, M. Rothenberger, and S. Chatterjee 2008. A design science research methodology for information systems research, *Journal of Management Information Systems* 24 (3), pp. 45–77.
31. Peterson, C. 2014. *Learning Responsive Web Design: A Beginner's Guide*., O'Reilly Media, Inc.
32. Pressman, R. 2010. Software Engineering: A Practitioners Approach. New York, Mc-Graw Hill.
33. Salami O.O. and Salami, O.O., 2013. The Factors Determining the Choice of Career Among Secondary School Students, The International Journal Of Engineering And Science (IJES), 33-44.
34. Sauro J.and Kindlund, E., 2005. A Method to Standardize Usability Metrics Into a Single Score, in Proceedings of the SIGCHI conference on Human factors in computing systems, 401-409.
35. Smith, S. and Kandel, A., 1993. Verification and Validation of Rule-Based Expert Systems, CRC Press.
36. Sommerville, 2007. Software Engineering. England, Addison-Wesley,
37. Subrahmanian E. and Davis, J.G., 1987. Validation of Expert Systems: Two Perspectives, in Seventh International Workshop on Expert Systems and Their Applications.
38. Turban, E. Aronson, J.E. and Liang, T-P., 2004. Decision Support Systems and Intelligent Systems (7th Edition). Upper Saddle River, Prentice-Hall, Inc.
39. Uko E.S. and Ayuk, A.A., 2013. Templates That Determines the Choice of Course Selection in the University: A Case Study of University of Calabar, Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS), 246-251.
40. Winston O. and Lawrence, M., 2008. Career Guidance Using Expert System Approach, in 4th annual international conference on computing and ICT research - ICCIR 08, Kampala, 123-131.
41. Yunusoglu M.G. and Selim, H. ,2013. A fuzzy rule based expert system for stock evaluation and portfolio construction: An application to Istanbul Stock Exchange, Expert System and Applications, 908-920.