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Requirements for the Development of an Ontology-Based Model for Efficient and Effective Delivery of Career Guidance: A Case of South-Western Uganda

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Abstract

As students transition between various stages of education and employment, they frequently struggle to make the best career choice due to the intricacy of selecting suitable career paths. This is due to unstructured career guidance (CG) data, the lack of trained career counsellors, the high student-to-teacher ratio of 3500:1 and the lack of standard CG policies and guidelines. As a solution to mitigate the above challenges, this research study proposes to develop an ontology-based model because ontologies have proved to be effective in structuring data as revealed by previous studies. However, ontology-based modelling requires extensive data thus this research aimed at establishing requirements for the development of an ontology-based model for the efficient and effective delivery of CG by generating an Ontology Requirements Specification Document (ORSD). This research study used mixed methods to carry out a cross-sectional survey involving all stakeholders in southwestern Uganda. The study recruited 384 participants who matched the inclusion criteria and consented to participate in the survey. Questionnaires were used to collect quantitative data which was analyzed using SPSS, and content analysis was used for qualitative data. Results reveal that 83.1% of the stakeholders among the participants reported having established CG programs in schools and 96.4% of the students reported having heard about CG. However, only 29.4% of the students had sufficient CG. Furthermore, 76% and 90.9% of students who participated in the survey from secondary schools and universities respectively reported that there is lack of enough career counsellors. In addition, 78.2% and 86.6% of student participants from both secondary and universities respectively reported that ICT has the potential to increase access to CG. Therefore based on these research findings, this research study developed a Requirement Specification Document that can be used as input for the development of an Ontology-Based Model for the efficient and effective delivery of career guidance.

Keywords: Career Guidance, Ontology, Requirements, Efficiency, Effective, Model

Introduction

Career guidance provides the opportunity for students to understand and identify their strengths, interests, skills, and values. One of the most crucial decisions a person will ever make is their career. However, many people find it challenging to make such choices and changes to the workplace in the twenty-first century have only made the process of considering career options and making a decision more challenging (Lindo et al., 2019). This is because career guidance is a complex and challenging activity since it involves in-depth knowledge of projecting future trends, as well as understanding the expectations of the employment industry and the most up-to-date skill set required for one to remain relevant and competitive internationally.

The 4th Sustainable Development Goal (SDG) is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (UN, 2015) with the main aim of ensuring that by 2030, all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes. This SDG is very

relevant because the ultimate goal for most school-going children is to be empowered in their journey for a meaningful career path (Startseva et al., 2019). However, the complexity involved in choosing an appropriate career path has led to several students making wrong career choices, negatively affecting the education and employment sector. The root cause of wrong career choices is primarily attributed to lack of appropriate, adequate and timely Career Guidance (CG) to help students classify, rank, and effectively gather the right information to make career decisions so that they can be empowered and guided towards achieving their dreams. Once students fail to make the right choice and at the right time due to a lack of appropriate, adequate and timely CG services coupled with unstructured CG data and information, their academic and professional life will negatively be affected as well as the efficiency of schools (Haji et al., 2014). In the long run, this will also have adverse effects on the employment sector due to failure to get employees with the required employment skills and interests. This partly explains the high rates of job turnover due to skills mismatch and lack of interest in the job.

During the career decision-making process, inconsistent information and a lack of expertise can lead to incorrect decisions. Furthermore, a vast volume of unstructured data must be managed systematically. Due to the lack of formal and structured CG, students' career choices have been influenced by teachers, parents or peers ("Int. Handb. Career Guid.," 2019) and this has negatively affected the professional sector and the development of the country. Orienting students and guiding them will not only offer considerable benefits in the employment sector (Abdellah et al., 2019), but will go a long way in the process of constructing a sustainable society by promoting both social and economic goals through its contribution to preventing skills mismatches, boosting productivity and also addressing social equity and social inclusion (Alimam et al., 2014). According to Anne et al. (2018) students who get solid career guidance and counselling are likely to make competitive career decisions while those who are not well supported may encounter problems in making life choices. Therefore, to mitigate such challenges that are likely to arise from lack of proper CG, a solution has to be sought to empower students with the required information to aid their decision-making while making career choices.

Due to the importance of CG and the ever-increasing population worldwide, the demand for CG services has exceeded its supply. Therefore, there is an urgent need to think of alternative technologies to supplement the available options like face-to-face sessions, websites, and recommendation systems among others. Due to scanty and unstructured data about career guidance, coupled with lack of qualified career counsellors, in this paper, we propose to use Ontologies to address these challenges. Ontologies have registered tremendous success in several domains like Biomedical Engineering (Kong et al., 2011) and (Mabotuwana et al., 2013), Clinical Research (Smith & Scheuermann, 2011), Agriculture (Liao et al., 2015), (Wei et al., 2012), and (Bonacin et al., 2016), Tourism (Abbasi-Moud et al., 2022), Construction (Bilgin et al., 2018), Aircraft (Zheng et al., 2021), Software Maintenance (Alsanad et al., 2019), Robotics (Fiorini et al., 2017) and Education (Costa et al., 2020). In Education, Ontologies have facilitated web searches for educational material, efficient automation of educational activities and processes, and exchange of information between educational institutions and institutional learning (Leon et al., 2017). This is because of their viability and effectiveness in developing applications requiring data and process interoperability, big data management, and automated reasoning on knowledge (De Nicola & Villani, 2021). The ability of Ontologies to provide standard terminologies and rich semantics to facilitate knowledge sharing and reuse is another strong justification for their popularity across domains. However, much as Ontologies have been widely and successfully used in other domains, there is scanty evidence documented in the literature about the application of Ontologies in CG. This research seeks to establish the requirements for developing an ontology-based model to address the lack of adequate CG and improve the efficiency and

effectiveness of 21st-century CG delivery by bridging the gaps created by limited access to CG due to unstructured data and lack of resources and personnel.

Background

The term 'ontology' is derived from the Greek words *Ontos* (being) and *logos* (word). It relates to both the study of being and the justifications for how being is structured, recognized, and classified. When used in the context of computer science, artificial intelligence, and information technology, ontology is regarded as a representational artefact for describing the semantics or meaning related to the knowledge or information in a certain domain in an organized way. Ontologies are formal knowledge models that describe concepts and relationships and enable data integration, information search and reasoning (Karl Hammar, 2019). Ontologies can further be described as a conceptualization of explicit information that consists of properties, concepts (also often referred to as classes), and relations between them (Schugerl, 2009). Ontologies, as opposed to databases, enable the use of incomplete knowledge (open-world assumption). Additionally, the use of ontological reasoning services and simple insensibility is made possible by their formal representation. Ontologies serve as a common language and are a crucial component of knowledge modeling and sharing. Traditional distinctions between knowledge resources are removed by this representation, which also serves as the foundation for knowledge inference (Munir & Sheraz Anjum, 2018).

By utilizing ontological reasoning services, developers can more easily access a wide range of information from various sources, providing an effective method for knowledge management (Schugerl, 2009). The ability of Ontologies to have a shared and common understanding of a domain that can be communicated between people and application systems has made them very popular and extensively used today (Chimalakonda & Nori, 2020). It is significant to stress that, similar to any complex domain, CG requires intelligent systems with extensive knowledge bases to reason about solutions to the issues they are intended to address. Such knowledge can develop into something that is both broad and complex internally, necessitating efficient software engineering methodologies for creation, application, and maintenance. Formal ontology concepts have long been used in artificial intelligence (AI) to address these issues. They provide an important tool for representing domain knowledge and reasoning within the domain, making it possible to create systems that can autonomously reason about problems in a semantically well-defined environment (Schlenoff et al., 2012). The collection of a wide variety of domain ontologies is one of the most crucial elements in the general creation and application of an ontology acquisition approach. Broadly speaking, one of the biggest issues with knowledge management is inefficiency. It is unnecessary to capture or recreate data that has already been recorded somewhere else.

The greatest benefit offered by ontologies is the ability to create large reusable ontology libraries containing organized, domain-specific, ontological information that can be put to diverse uses for several application situations—instead of having to encode information multiple times in different application settings (Bateman et al., 2018). This will offer tremendous benefits in the CG domain by structuring CG information to the benefit of all stakeholders. Another important benefit why ontologies have become very popular both in computer science and AI, and ought to be adopted in CG is the ability to develop software systems that facilitate knowledge sharing. The substantial corpus of research devoted to the creation of instruments and techniques to enable a knowledge-sharing approach to integration serves as proof of the significance of knowledge and information sharing which is offered by ontologies. However, ontology reuse continues to be a major issue for the community despite numerous initiatives to promote and enable it (Benjamin et al., 2006). The situation becomes worse in domains like CG where little research has been done to provide a basis for re-using

existing ontologies. Therefore this research opted to conduct a cross-sectional survey to establish the requirements for developing an Ontology-Based Model.

Methodology

This research was conducted using a mixed-methods approach. Quantitative data was gathered through a questionnaire to help determine the requirements for creating an ontology-based model for effective career guidance. This instrument was selected due to its capacity for acquiring precise primary information for the model. To guarantee that results remained constant across time, the questionnaire's validity and reliability were assessed before it was used. Additionally, interviews were performed to gather qualitative information to better comprehend the specifications and aid the design. The sample size was determined using the Krejcie and Morgan (Krejcie & Morgan, 1970) formula. A multistage sample approach was used to recruit 384 participants from southwestern Uganda for the study. Five districts were purposively selected in the first round. This is because these districts have both public and private universities that admit students from all over the country as well as international students. This helped to reduce bias in the results. In the second round, fifteen (15) schools were randomly chosen from the five districts, with a minimum of three schools per district. Seventeen (17) students were randomly selected from each school making a total of 255 students from secondary schools who were given questionnaires. From each school, the career master's teacher was inter- viewed making a total of 15 career masters that participated in the study. Additionally, six universities were chosen randomly selecting 15 students from each University making a total of 90 students from Universities. Each Academic Registrar from their respective University was interviewed. Finally, eighteen (18) employers were randomly chosen with at least three employers per district. Quantitative data was analyzed using SPSS and the study findings helped establish requirements for the design and development of the Ontology-based model. The findings of the study are presented in form of bar graphs. Thematic analysis was used to explore qualitative data.

Demographic Characteristics

The survey had a total of 384 participants (Table 1). These included 255 secondary school students of which 54.4% were females and 45.6% were males, 90 university students of which 60.5% were males and 39.5% were females; 15 career masters; 6 Academic registrars and 18 employers.

Table 1: Selection of respondents

Category	Number
Number of Districts	5
Number of Universities	6
Number of Students per University	15
Total number of University Students respondents	90
Academic Registrars	6
Number of Secondary Schools Per District	3
Total Number of Secondary Schools	15
Number of Students per School	17
Total Number of Secondary Schools Students Respondents	255
Number of Secondary Teachers Respondents	15
Number of Employers	18
Total Number of Respondents	**384**

Results

Knowledge about Career Guidance and Source of Career Information

Students' knowledge/awareness and sources of CG in schools and universities were assessed by asking them if they had heard about the concept of CG, and if yes, where they got the information from. Interesting results were obtained revealing that the majority of the students (60.6% and 35.8%) of secondary school students and (50.1% and 42.7%) of university students strongly agreed and agreed respectively to have heard about the concept of CG as indicated in Figure 1.

The research also established that the majority of the participants (50.7% and 58.5%) secondary and university students respectively got CG from their secondary school teachers, followed by parents at 20.5% and 14.7%, social media at 3.5% and 18.1% TVs and radios at 8% and 18.1% and other sources at 5.2% as indicated in Figure 2.

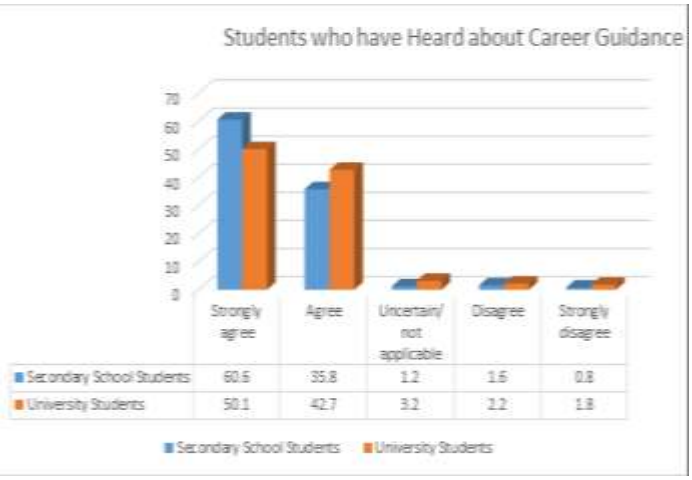

Figure 1: Knowledge about Career Guidance

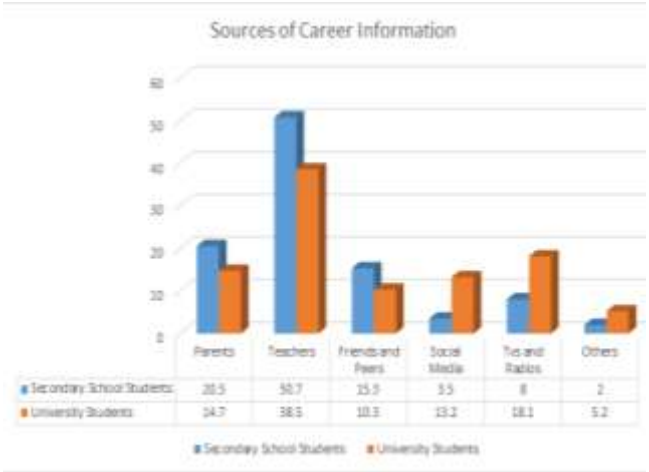

Figure 2: Sources of Career Guidance

Although most of the students reported getting information about CG from various sources, Figure 3 reveals that they did not get sufficient information as indicated below.

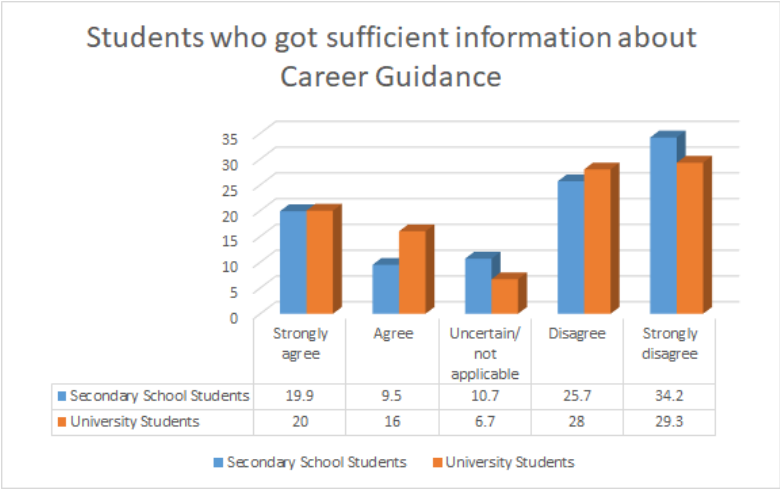

Figure 3: Sufficient Career Guidance Information

Availability of CG Programs in Schools/Universities

Given the value attached to the importance of CG and the need to be extended and availed to all students, it was paramount to find out if schools and universities have CG programs and if all students benefit from these programs. Results from the survey indicated that the biggest percentage of schools that participated in the survey had CG programs. However, it is the opposite with universities, as the majority of the respondents indicated that they do not have CG programs in universities as indicated in Figure 4.

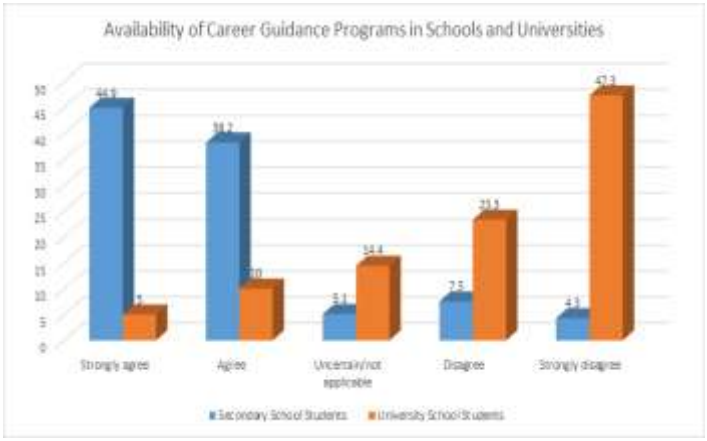

Figure 4: Availability of Career Guidance program

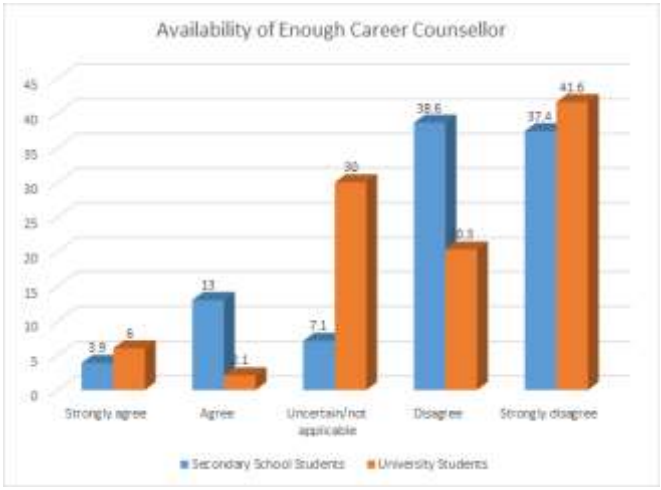

Figure 5: Availability of enough career counsellors

Having established the importance of CG to both secondary and university students, it was also important to establish whether there were enough trained and competent career counsellors to provide CG to all students. Although most schools reported having CG programs, results obtained from the survey indicated that schools did not have enough CG counsellors. Similar results were obtained from universities revealing that there is a general scarcity of career counsellors.

Discussion

This research considered a fairly uniform distribution of gender. This was to ensure gender representation as advocated for by the 5th SDG which aims at creating a world where girls and women have equal access to education, the job market, respect, and the ability to live freely (Voituriez et al., 2017).

The research established that the majority of the students have knowledge about CG. This implies that CG is not a new phenomenon to students as similar results were obtained by (Otwine et al., 2022). This research established that teachers are the main source of career information followed by parents. This is because students spend most of their time at school. When they go back home for holidays, they get a chance to interact with parents some of whom may pass on some career information. This is common in cases where parents dictate the career path to be taken by their children (Obwoge & Kibor, 2016). Secondary school students reported social media as the least source of career information. This is true because all the secondary schools that participated in the study do not allow students to carry mobile phones at school. However, university students recorded a higher percentage from social media because they own smartphones and spend most of their time on social media. However, it should be noted that although students spend most of their time on social media, they are looking for other things and not career information (Kara, 2019). This also explains why TVs and Radios scored

a low percentage in secondary schools and a slightly higher percentage among university students.

This research, however, disagrees with the findings by Otwine et al. (2022) who reported that the majority of the students (88.2%) get career guidance and counselling information through interaction with professionals, followed by progressive tests at 75.8%. This research established that most of the schools only bring in professionals towards the end of their third term to guide Senior six (S6) candidates. I quote *"As we prepare students to fill the Public Universities Joint Admissions Board (PUJAB) forms, we invite an expert from public universities like Makerere University or Mbarara University of Science and Technology to come and talk to students about programs in public universities, their entry requirements and cut off points. This is done to help students prioritize their choices as they fill the PUJAB forms, to increase their chances of qualifying for government merit scholarships".* These findings contend with Otwine's research whose results were based on 161 students in S6 students from four schools. However, data from only S6 candidates may not be representative as reflected in Otwine's research. Furthermore, these workshops with professionals are for a few hours, providing specific information that may not be sufficient to address all career needs of the students. The sustainability of such activities is also questionable because hiring facilitators is very expensive.

Furthermore, findings from this research concur with (Alimam et al., 2014) that teachers influence most of the career decisions made by students who indicated that Schools are essential in helping children develop their objectives for future academic pursuits because students spend most of their time with teachers. However, students' evaluation is manually done at the end of middle school which may be late for them to make changes in their career paths. Due to time constraints, an increase in students' enrollment and a myriad of career paths, manual personalization is no longer feasible. Similar findings were established by Robert (2016) who observed that schools pay more attention to completing content in the syllabi/curricula and other co-curricular activities leaving them with no time to offer CG to students. Based on the findings from the survey backed up by evidence from the literature, it is evident that teachers are overwhelmed with school activities with no time to offer effective CG. Therefore, this research concurs with the recommendation by (Alimam et al., 2014) to adopt new technologies and tools like Ontologies to simplify the process of providing timely and effective CG to all students which will benefit both the educational environment and research.

Although the majority of the students indicated having gotten CG from teachers as indicated in Figure 2, results obtained in Figure 5 were very worrying indicating a general lack of career counselors both in secondary schools and universities. Lack of career counselors is a general problem not only in Uganda but in most of the developing countries in Africa as indicated in the research by Sowunmi et al. (2016) who established that career counselors are either insufficient or nonexistent in the majority of secondary schools in Africa today. As a result, students do not have adequate access to counselling services and choose their careers without consulting professionals or taking into account the necessary factors. This explains why the majority of the students both in secondary schools and universities reported that they did not get sufficient information as indicated in Figure 3. Due to lack of adequate CG, students end up making irrational decisions similar to those of their peers or based on the perceived prestige and popularity of particular academic majors that may not meet the trending Job opportunities of the 21st century. Although (Kibui, 2011) promotes peer and group counseling techniques in schools as a way to enhance access to career information, it is crucial to emphasize that his study overlooked the significance of giving peer counselors training to prepare them to handle students' issues successfully. Relying on peers for career guidance entails a considerable risk of supplying inaccurate information that could negatively impact

students' futures. Based on these findings, therefore, embracing technology with the use of Ontologies will help address this challenge of lack of career counsellors by structuring all career information and forming a resourceful pool of information that will form a one-stop centre for all career information without necessarily having to rely on career counsellors who are inadequate and ill-equipped with the required up to date information to guide students.

ICT has played a great role in improving service delivery in several sectors (Barakabitze et al., 2019; Usak et al., 2020). Results obtained in Figure 5 indicated that the majority of the respondents strongly agreed that ICT has the potential increasing access to CG information. However, although ICT has the potential of increasing access to CG, it is paramount to think of the best ICT solution that will serve the purpose. Several ICT tools like websites, recommendation systems, and social media have been proposed by researchers (Supriyanto et al., 2019; Zainudin et al., 2020), but they all have their setbacks and none of them has the potential of providing a one-stop center for CG information. The range of career options available in today's work environment is the most noticeable feature of career choices. Career selection in the twenty-first century is a lifelong process with several steps and countless transitions that are not always centered on a specific goal, but rather on coping with unanticipated changes and opportunities. While the Fit approach focuses on the relatively static congruence between persons and their employment as advocated for by most career counsellors, teachers, parents and peers, the modern work world necessitates an understanding of the changing nature of career decisions. As a result, rather than the classic linear, progressive vision of a career path, the post-modern career path can be described as a path with many forks, each presenting multiple paths to examine. This forms one of the most important requirements addressing the purpose of the ontology and intended users and uses while developing the proposed ontology-based model for improving the effective and efficient deli of timely CG.

Furthermore, CG should not only target students seeking to find suitable jobs/careers. Adults of all ages now make up the clientele for career counselling, which previously only served teenagers. However, defining and achieving personal goals as well as improving quality of life continue to be the main aims of guiding. The fundamental procedures of guidance have been improved throughout time and now cover a wide variety of services, from information to advice and placement ("Int. Handb. Career Guid.," 2019) hence the reason for proposing the retirements module and work-life balance as part of the requirements in the proposed model. Making a career decision requires gathering pertinent information, which must then be processed.

However, to provide efficient CG, one must consider a huge number of prospective career options, the subtle differences between them, and the regular changes they go through. Due to the complexity, volume, and sensitivity of the data involved as well as the multifaceted understanding of career guidance, this approach may be better carried out with the aid of computer-assisted systems that can gather and logically analyze a significant amount of data from various sources to produce decisions about coherent, sustainable, and useful career paths (Hassan et al., 2022). Ontologies are intelligent technologies that can reason and draw appropriate conclusions, which are needed to handle the issue of managing this information deluge. Therefore, it is against this background that this research set out to establish requirements for the development of an Ontology-based model for effective and timely delivery of CG to all stakeholders that will address the needs of the 21st century. The output of the ontology requirements specification is an Ontology Requirements Specification Document (ORSD) that aids the development of Ontology.

Ontology Requirements Specification

The goal of the Ontology Requirements Specification activity is to state why the ontology is being built (purpose/goal of the ontology), what its intended uses are, who the end-users are,

and which requirements the ontology should fulfil (Suárez-Figueroa et al., 2009). Competency questions (CQs) are always used for establishing ontology requirements. Several guidelines have been proposed to help ontology developers in the ontology requirements specification activity. Such guidelines have been created in the context of the NeOn methodology (Suárez-Figueroa et al., 2009) for building ontology networks.

Several ontology developers recommend using NeOn methodological guidelines described using a filling card for the ontology specification activity, including the definition, goal, inputs and outputs, who carry out the activity and when the activity should be carried out.

Based on the survey results and discussions in the section above, the following requirements were established for the development of an ontology-based model as shown in Table 2.

Table 2: Ontology Requirements Specification Document

	Ontology Requirements Specification Document for developing an Ontology-Based Model for CG
1	**Purpose**
	The purpose is to develop an ontology-based model to enhance the effective and efficient delivery of CG for learning, employment and skills development strategy.
2	**Scope**
	The ontology will focus on the Career Guidance domain and the competency questions and phrases specified will directly affect the amount of specificity.
3	**Implementation Language**
	The ontology will be developed using Web Ontology Language (OWL)
4	**Intended End-Users**
	User 1: Secondary school students User 2: University students User 3. Teachers especially career masters in secondary schools User 4: University administration especially Academic Registrars and Deans of students User 5: Employers seeking to recruit employees with relevant skills and to bridge the gap between universities and the industry. User 6: Candidates who are employed and need advice concerning changing careers or information regarding preparation for retirement User 7: Head Teachers for secondary schools to incorporate CG in school calendars User 8: Ministry of Education and Sports - department of Guidance and counselling.
5	**Intended Uses**
	Counsellors
6	**Ontology Requirements**
	a) Nonfunctional Requirements (NFR)
	NFR 1: Requirements were collected in English, hence the ontology will support English language NFR 2: The ontology should support users at all levels, from secondary school, university, industry to retirement.
	b) Functional Requirements: Competency Questions
	CQ1. What is Career Guidance? CQ2. What are the benefits of CG? CQ3. What career path do you want to take? CQ4. What subjects/combination leads you to that path?

	CQ5. If you do not make it to A level, what next? CQ6. What programs will you do if you choose a certain combination? CQ7. Which Universities offer the selected program? CQ8. What is the duration of the chosen program? CQ9. How much tuition is paid in that University for that program? CQ10. What companies or organizations provide internships in your program? CQ11. What are the career ladders in your chosen career path? CQ12. What kind of skills do you need to meet the market demands of the 21st century? CQ13. What career opportunities are in that career paths CQ14. How much salary is paid in that employment field? CQ15. What risk are involved in this career path? CQ16. How are you prepared for retirement?	
7	**Pre-Glossary of Terms**	
	Career Guidance Career path Combination University Program Duration	Tuition Organization/company Internship Career ladder Skills Salary Risks Retirement

Table 2 summarizes the requirements gathered from the survey and findings from literature. The requirements will form the basis for the development of an ontology-based model for improving the delivery of timely efficient and effective CG.

Conclusion and Future Work

The application of Ontologies in the CG domain can potentially improve the delivery of effective, efficient and timely CG to the benefit of all stakeholders. Due to lack of existing ontologies in the CG domain to build from, the survey conducted in this search established the key requirements to aid the design and development of an ontology-based model for effective CG. These requirements are summarized using the ORSD showing the purpose, scope, implementation language, ontology requirements both the functional and non-functional requirements and the pre-glossary of terms. CG being a lifelong journey, should not only end at guiding students but also people who are already employed. This research also established that although CG is very important in shaping people's careers by helping them make the right career decision, the delivery of CG is still lacking both in secondary schools and universities. Lack of dedicated time for CG, lack of trained personnel, and complexity in choosing career choices due to the inability to make sense of relationships in unstructured data are some of the challenges that have complicated the CG process hence the need for automation using intelligent tools like Ontologies. Furthermore, it has been established that for CG to make sense, the proposed ontology model should target the 21st-century CG needs that will be able to address the current work demands. Some of the features of the 21st century that must be incorporated in the proposed ontology model include but are not limited to; effective communication skills, multi-track careers, collaboration skills, continuous learning utilizing online courses, a proposal for funding writing skills, and entrepreneurship skills among others.

Recommendations and Future Work

Based on the findings and discussions, this research recommends developing an ontology-based model using the ORSD. This development should be done with users utilizing user participatory approaches that advocates for developing with users as opposed to developing for users. Domain experts like career teacher, Academic Registrars and employers should be made part of the designing and development team. This will make users accountable for the final model which will increase usability.

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