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## A Systematic Review on the Application of Ontologies to Improve Career Guidance

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### ABSTRACT

The review discusses students' challenges as they move between educational levels and the labor market, mainly due to the lack of effective, efficient, and timely career guidance. The review suggests that using ontologies can improve career guidance delivery by providing a structured approach to representing and organizing career-related data. The study conducted a systematic literature review and found that ontologies have not been extensively applied in the career guidance domain. The review highlights the unique advantages of using ontologies for career guidance (CG), such as formal representation, interoperability, and knowledge representation and reasoning. The review also points out the loopholes in the few studies that attempted to use ontologies in CG. A systematic literature review was carried out to assess the extent to which ontologies have been applied in CG. Four reviewers performed a systematic search in IEEE, Scopus, Web of Science, and Google Scholar independently using agreed-upon criteria. To eliminate the bias of leaving out important studies, abstracts from selected conferences were carefully screened and reference scanning of the search results was performed. Out of 307 studies, 11 were found to match the search parameters and were included in the study.

### INTRODUCTION

Career Guidance is a process that aids people in discovering and developing their interests, values, abilities, and goals as well as assisting them in making decisions about their future in learning, employment, and other pursuits (Roy, 2020). Transitioning between the different levels of education and the labor market is one of the biggest challenges experienced by students worldwide and this is mainly attributed to a lack of timely, effective, and efficient CG (Pordelan & Hosseinian, 2022). Many students have made poor career decisions due to the difficulty in selecting an acceptable career path, which has negatively impacted the education and employment sectors as well as wastage of time, resources, and lack of motivation for work (Afaq Ahmed et al., 2017). The absence of relevant, sufficient, and timely CG for students who are required to make a career decision at a relatively young age is the primary cause of

students making the wrong professional choices since this prevents them from being inspired and guided toward fulfilling their aspirations. In the context of career choice alternatives, students need to be educated on recent developments, prospects for the future, and problems. They must be knowledgeable of the current market trends, business practices, and employment landscape across all industries (Afaq Ahmed et al., 2017).

Even though the fourth Sustainable Development Goal (SDG) is to ensure all people have access to high-quality, inclusive, and equitable education and to encourage opportunities for lifelong learning, (General Assembly, 2015), students often struggle to make the best decision at the right time due to inadequate CG services, unstructured CG data, a shortage of career counselors with training, 3500 students per instructor is a high student-to-teacher ratio, and there aren't any established CG regulations or

standards (Haji et al., 2014). The lack of workers with the required interests and skills will have detrimental long-term effects on the employment industry (Suarda et al., 2017). This aids in partially explaining the high rates of job turnover brought on by the incompatibility of skills and a loss of interest in employment (Nawaz & Pangil, 2016).

The professional sector and the development of the nation have suffered as a result of the lack of appropriate CG, which has allowed parents and peers to influence students' careers (Arshad et al., 2018). In addition to having a big impact on the employment market (Abdellah et al., 2019), orienting and guiding students will also have a big impact on building a sustainable society by advancing both social and economic goals (Elyusufi et al., 2014). This is because it helps avoid skill mismatches, increases productivity, and addresses social equity and social inclusion.

It has been established that students who receive timely, effective, and efficient CG and counseling are more likely to choose competitive careers and become successful in the future compared to their counterparts who are not well-supported in choosing an appropriate career path. These students may find it difficult to make wise career selections. To avoid the challenges that are likely to come from insufficient CG, a solution must be found to give students the information they need to support their judgments while thinking about career options (Anne et al., 2018).

Due to the importance of CG and the consistently expanding global population, the need and desire to have effective and timely career guidance services have outpaced its supply. When it comes to assisting students in discovering the vast number of options that make up the professional world, information, and communication technology can be quite helpful (León & Castro, 2014). Therefore, there is a pressing need to consider new technologies to complement the current options, which include in-person meetings, websites, and recommendation systems, among others. Although the integration of ICT into career practice has come a long way, there is always potential for growth (Bimrose et al., 2015). Researchers have paid little attention to using artificial intelligence to support CG in higher education and the workplace. This creates a big loophole and yet another opportunity for researchers to explore the extent to which

ontologies can be applied in the CG domain, just as they have been successfully used in other domains like Biomedical Engineering (Mabotuwana et al., 2013; Megan Kong et al., 2011), Clinical Research (Smith & Scheuermann, 2011), Agriculture (Bonacin et al., 2016), Construction (Çevikbaş & Işık, 2021), Aircraft (Çevikbaş & Işık, 2021), Software Maintenance (Roldan-Molina et al., 2020), Robotics (Prestes et al., 2021) and Education (Prestes et al., 2021).

By effectively automating educational tasks and procedures, ontologies in education have made it simpler to access educational content online and to share data amongst institutions of learning. This is due to their ability to develop systems that successfully require huge data management, automated knowledge reasoning, and process and data interoperability. Another convincing argument for the widespread usage of ontologies is their capacity to provide consistent terminology and comprehensive semantics to promote knowledge exchange and reuse (Dse Nicola & Villani, 2021).

Despite the widespread and effective use of ontologies in other fields, there is little evidence to support their use in career counseling that has been published in the literature. This lays the groundwork for why, in this study, we conducted a systematic literature review to determine the degree to which ontologies have been applied in the career guidance domain.

Different definitions of ontologies exist. The formal knowledge models that enable data integration, search, and reasoning as well as an explanation of concepts and connections is one of the definitions that are most frequently employed (Hammar, 2017). In addition, ontologies have been described as a conception of explicit knowledge made up of qualities, concepts (sometimes referred to as classes), and their interactions. Unlike databases, ontologies enable you to work with partial information (open-world assumption) (Chimalakonda & Nori, n.d.).

It is crucial to keep in mind that, like any complex field, CG requires automated systems to have access to a wealth of knowledge to make decisions concerning the problems they are meant to solve. To produce, use, and maintain such information effectively, good software development approaches are needed. Such knowledge might

grow broad and sophisticated in its internal organization. The use of formal ontology concepts to address these difficulties has long been widespread in artificial intelligence (AI) (Bateman et al., 2018).

## **METHODS**

### **Scoping Review Methodology**

A scoping review is a strategy that tries to review the literature that has, up until now, gotten little attention among researchers or where the research area is complex (Arksey et al., 2007). According to Arksey et al., to successfully use this methodology, six key steps were proposed and these include i) identifying the research question, ii) identifying relevant studies; iii) study selection iv) charting the data v) collating, summarizing, and

reporting results and vi) consultation. For this review, a scoping review technique was used because it enables researchers to swiftly assess the body of literature on the topic (career guidance) and allows the inclusion of a variety of study types, lowering the possibility of bias in the conclusions. (Arksey et al., 2007).

### **Identification of Studies**

A highly sophisticated search approach was used to locate, screen, and analyze all publications that addressed the application of ontologies in career guidance/counseling that were published during the last 15 years, which is regarded as contemporary research. A preliminary database search turned over 300 publications, of which only 11 satisfied the inclusion requirements, as shown in Table 1.

<b>Author and year</b>	<b>Title</b>	<b>Study details</b>	<b>Weakness / Gap</b>	<b>Proposed Improvement</b>
1. Obeid et al., (2022)	A Novel Hybrid Recommender System Approach for Student Academic Advising Named COHRS, Supported by Case-based Reasoning and Ontology	The system aimed at helping high school students using a hybrid recommender system that offers specialized predictions based on their interests.	The recommendation system targeted high school students as they transition to University. This is not timely because helping a student choose a university major does not guarantee making the right choice.	Timely delivery of career information.  Provide rich career information for students to make informed decisions instead of making decisions based on predictions.
2. Bakke & Hooley (2022)	Mapping the Future of Undergraduate Career Education.	The research advocated for Integrated career assistance as a method of providing career help that makes use of digital technologies like ontologies, in-person encounters, and any other strategies that are beneficial to students, like the distribution of printed materials.	The research advocated for the integration of CG using several methods, including outdated methods like printed materials which are very costly, in-person encounters which are ineffective due to a lack of enough and qualified career counsels.	An ontology-based model that structures all the CG information into a one-stop center that allows users to find what they are looking for easily and in a much more organized way.
3. Dascalu et al., (2022)	An ontology for educational and career profiling Based on the Romanian occupation classification Framework: Description and scenarios of utilization	The study's goal was to create smart platforms or recommender systems that would offer personalized educational and professional counseling to solve Romania's shortage of job counselors.	Focuses on recommending jobs to students based on their interests and profiles.  Based on the Romanian national classification of occupations which may not be applicable in other regions	Provide timely information in an efficient way that will help a student to make an informed career decision, other than having the decision controlled by a recommender system

4. Majid et al., (2021)	Ontology-Based System for Educational Program Counseling	The study developed an integrated system that effectively extracts user-specific limitations in unambiguous queries and then retrieves more accurate data about educational fields and associated institution offerings.	<p>Focused on University students</p> <p>Data was based on user queries and extracts from the internet which may not be accurate</p>	A model that targets all groups of people and not only university students.
5. Ibrahim et al., (2019)	Ontology-Based Personalized Course Recommendation Framework	The study suggested a framework for an ontology-based hybrid filtering system to aid students in identifying pertinent university courses that fit the unique demands of users.	All challenges of recommendation systems apply	A model that will eliminate the challenges of recommendation systems
6. Abdellah et al., (2019)	Career Recommendation System for Scientific Students Based on ontologies	Although career choice is fundamental to the future of the individual. It was established that the assignment is done in an unqualified and unreliable way.	<p>Based on the 19<sup>th</sup> and 20<sup>th</sup>-century career theories which should be reformatted.</p> <p>Based on Holland's theory that assumes a stable environment.</p> <p>The Model heavily relies on scientific methods developed at universities under controlled conditions.</p>	<p>Life work balance</p> <p>Inform students of the risks involved in all occupations and the ever-changing technological needs.</p> <p>Adopt the 21<sup>st</sup>-century skills</p>
7. Startseva et al., (2019)	Ontology rules application for efficient career choice	The ontology aimed to help university applicants in their transition phase from high school to tertiary education starting with their first life-long decision concerning their choice of field of study.	<p>Targeted only university applicants.</p> <p>Based on Spanish high school students specializing in three study programs (Natural science, social studies, and arts &amp; humanitarian studies)</p>	<p>A model based on Uganda's education system</p> <p>Incorporate all areas of study including vocational training.</p>
8. Obeid et al., (2018)	Ontology-based Recommender System in Higher Education	Empower students with the information they need to choose a course of study that will best serve their long-term professional and academic objectives.	<p>It's a recommendation system with all the challenges of recommendation systems</p> <p>Lack of personalization, Limited scope, Bias, Lack of transparency, and Incomplete information among others.</p> <p>The main aim is to help university students find relevant majors</p>	<p>A model that will align with a person's goals, values, or preferences,</p> <p>Provide all the data required for anyone to make an informed career decision by capturing the full range of career opportunities and paths.</p>

9. Robles-gómez et al., (2016)	Defining a Novel Ontology for Educational Counselling based on Professional Indicators	Utilizing information from Social networks for employability needs.	Information from Social network sites can not be relied on to make concrete decisions that will impact the future of someone.	A model that is based on factual data and mot social media information.
10. Haji et al., (2014)	Multi-expert system design for educational and career guidance: An approach based on a multi-agent system and ontology	CG knowledge comes from four sources: pedagogical experts, psychological expert, sociological expert, and economic expert	CG is so wide to assume that knowledge can only be got from the 4 areas.  Based on the building of profiles.	To incorporate all key players and all sources of CG knowledge
11. Alimam et al., (2014)	Building profiles based on ontology for career recommendation in the E-Iearning context.	The recommendation system allows the construction of a student profile based on his / her aspects of personalization and reflection in learning	The Moroccan Education system is different from Uganda's Education system.  The system is applied while students are in their final year (9 <sup>th</sup> Grade)  The system bases its resolution on Cumulative Grade Point Average (CGPA) and this may affect some students.  The system is meant to degree students	Model based on Uganda's Education system as guided by the scope of this research.  Providing career guidance to students at an early age than waiting for them as they join the University

The review intended to determine the extent to which ontologies have been applied in the CG domain, the gaps and limitations encountered when applying ontologies in CG, and provide ways to remedy these issues.

### Search Strategy

During the review, publications spanning 15 years were reviewed related to the application of ontologies in the CG domain. Various electronic sources were utilized to ensure the required information was gathered without bias. For accurate results, the search process was automated on specific scientific online electronic databases related to computer science by building search queries based on agreed-upon keywords (Ontology or ontologies AND Career guidance OR Career counseling). The main focus was put on IEEE Xplore, Scopus, Web of Science (WoS), and Google Scholar. The review was carried out following three (3) main phases. The first stage consisted of searching to review the popularity and

interest of scholars regarding the application of ontologies in CG. It was established that about 307 papers in IEEE Xplore, Scopus, Web of WOS, and Google Scholar are related to the application of ontologies in CG. The second phase was screening, to find out only studies specifically on the application of ontologies in CG published in the last 15 years. Out of the 307 papers extracted, only 11 studies met the inclusion criteria, which clearly shows that there is a big gap in the application of ontologies in CG that needs to be addressed. To avoid bias arising from leaving out articles related to the review, the bibliographies and reference lists of the included studies were also further scrutinized. All extracted search query results from the selected databases were independently examined as CSV files for inclusion based on title, abstract, and full text.

### Inclusion Criteria

The inclusion/exclusion criteria are so vital in ensuring that the study does not deviate from the

research topic and objectives. All relevant articles related to ontologies in the CG domain were considered suitable for the study. For purposes of this article, the following inclusion criteria were followed:

1. Peer-reviewed articles
2. Studies published in English
3. Studies published between the period of 2008 and 2023
4. Studies based on the application of ontologies in Career Guidance/Career Counseling.
5. Full research papers

**Exclusion Criteria**

1. Non-peer-reviewed published information
2. Studies not published in English
3. Duplicated works in Electronic databases
4. Studies outside the domain of ontologies in Career Guidance/Career Counseling

**Data Extraction and Analysis**

At this stage, the relevance of each document was assessed before considering it to be part of the study. Analysis was mainly based on the document title and content of the abstract. However, there were instances where it necessitated reviewing the full body text aimed at clearing any doubts.

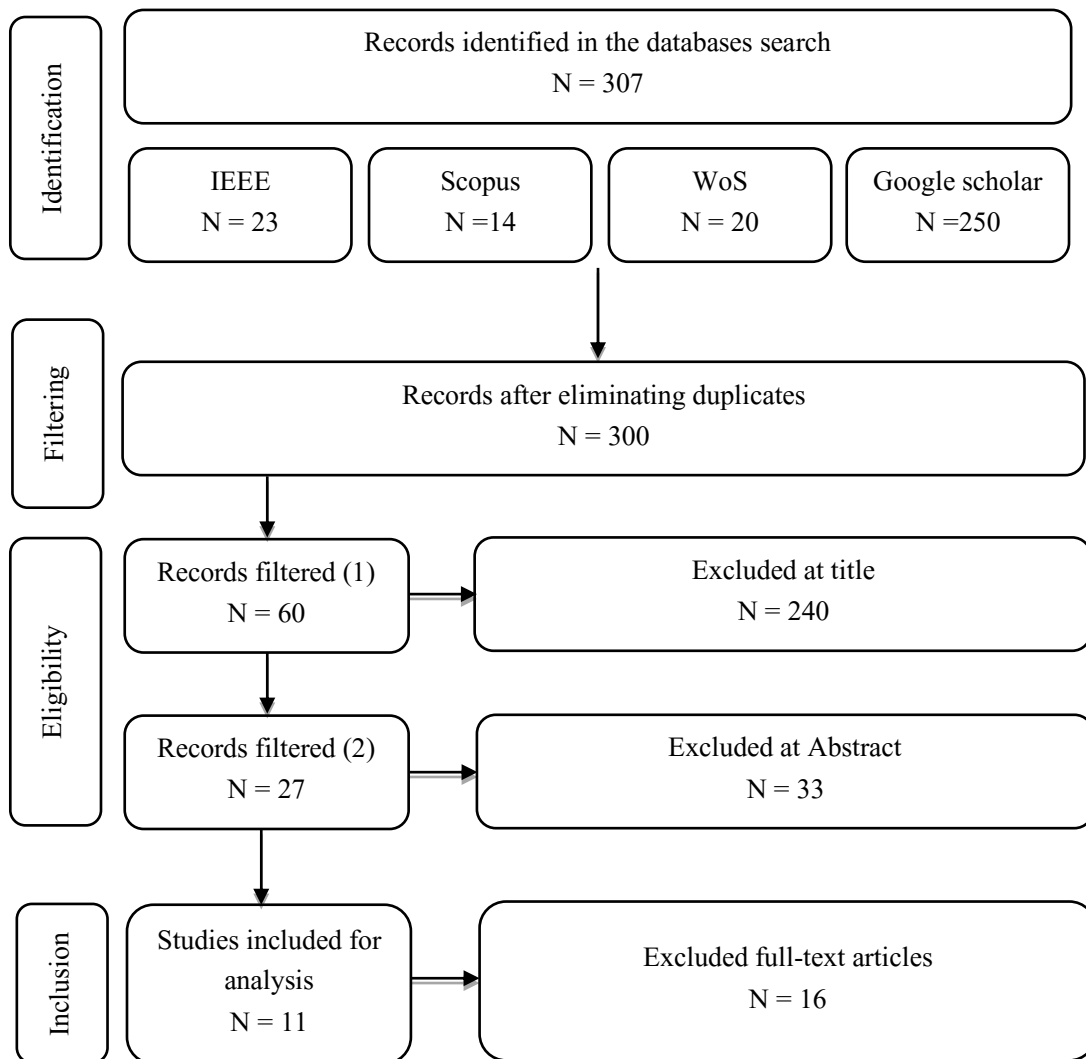


Figure 1: Flow diagram for the selected studies

**RESULTS AND DISCUSSION**

Career guidance has been a fundamental component of schools for a considerable duration, to aid students in contemplating their goals, passions, credentials, and skills. The aim is to assist

students in comprehending the job market and education systems, aligning this with their personal needs, and nurturing their sense of global citizenship. Through comprehensive career guidance, students learn how to plan and make

decisions about their work and education while also managing their career skills and progression. Through the organization, systematization, and timely presentation, career guidance aims to increase access to information about the labor market and educational prospects (Do & Nguyen, 2015). For this to be achieved, there is a need to think of better ways of delivering CG to supplement the available delivery methods.

Information and Communication Technology (ICT) is frequently employed in career counseling for students. Making better use of ICT can increase students' access to career information and act as a resource for making better career decisions (Supriyanto et al., 2019). Research by (Kalungi et al., 2023) also established that ICT has the potential of improving the delivery timely effective, and efficient delivery of CG by utilizing artificial intelligence technologies like Ontologies.

ICT has dramatically changed society over the past two decades as a result of its rapid growth. People now have unparalleled access to a wide range of information, allowing for low-cost, around-the-clock communication on a global scale (Kettunen et al., 2020). This calls for a continuous re-evaluation of techniques and delivery methods by CG professionals if they are to provide meaningful and effective career services that meet the demands of the 21st century. The demand for CG services has outpaced their supply, which has increased the urgency for better ways of integrating career guidance services and related professional practices with new technologies to enable people to easily explore and acquire information about opportunities for education, training, and employment (Lavicza et al., 2021). The use of ICT in providing CG is also referred to as technology-assisted career counseling which is provided in many forms and for different purposes. As opposed to face-to-face counseling, technology-assisted career counseling involves the use of online sites and online career assessment tools like career recommendation systems which provide avenues for information gathering and job search. Another form of utilizing ICT to support CG is by contacting counselors in a virtual world using telephone counseling, email counseling, and online chat (Zainudin et al., 2020) or online career counseling websites (Pordelan & Hosseinian, 2022).

Despite the potential benefits of utilizing ICT in career interventions like increased access to

career information, assessments, peer and practitioner support via social media, and reduced costs in creating and delivering career resources and services, several limitations have hindered the effective delivery of CG services to the satisfaction of the end users and stakeholders (Pordelan & Hosseinian, 2022). It is against this background therefore that this research opted to evaluate the extent to which ontologies have been applied in the CG domain by identifying studies that have focused on the application of ontologies in CG. Having successfully been applied in other domains, ontologies have the potential of improving the delivery of timely, efficient, and effective CG by capitalizing on the benefits of ontologies like improved knowledge sharing and reuse, increased accuracy and consistency, facilitation of automated reasoning, support for semantic interoperability, enhanced data integration and interoperability, better decision making, and improved knowledge management (Kulmanov et al., 2021).

The use of ontologies in the career guidance field can offer a consistent and structured approach to conveying knowledge related to careers, which can lead to better and more productive career guidance and counseling. Nevertheless, to successfully incorporate ontologies into career guidance, there needs to be cooperation between all stakeholders like students, parents, career counselors, Institutions of Higher Learning, employers, and technology firms to guarantee that the ontology is all-encompassing, precise, and kept up-to-date (Kalungi et al., 2023). Involving users in the design of an artifact is referred to as participatory design (PD), a technique that is showing a growing interest in educational researchers whose main principle is to grant all users a say and influence over the design outcomes to increase transparency and accountability (Cumbo & Selwyn, 2022).

Findings from the literature have indicated that there is scanty evidence about the application of ontologies in CG. It was established that only 11 studies met the inclusion criteria. Of these 11 studies, 6 of them, that is (Alimam et al., 2014), (Obeid et al., 2018), (Obeid et al., 2022), (Dascalu et al., 2022), (Ibrahim et al., 2019), and (Abdellah et al., 2019) proposed recommendation systems to help students during the career pursuit. However, each of these studies had its shortcomings as

indicated in Table 1, hence the need to address these shortcomings/loopholes by proposing an Ontology-Based Model (OBM) that would provide a one-stop center for all career guidance needs, by providing information to students from the time they choose a combination/major to the time they gain meaningful employment by providing them with the required skills that meet the needs of the 21<sup>st</sup>-century world of work. Research by (Kalungi et al., 2023) established the requirements needed to develop an OBM that would help to address some of these challenges.

Most of the studies that have attempted to apply ontologies in CG based their recommendations on the 19<sup>th</sup> and 20<sup>th</sup>-century CG theories of Supper (Super et al., 1992) and Holland (Holland, 1972) for Working one's way up the career ladder by doing what it takes for someone to get promoted by Visualizing their dream job and develop the skills to have that Job, considering a static environment. Furthermore, it should be noted that the 19<sup>th</sup> and 20<sup>th</sup> century CG theories do not address the needs and current demands of the 21<sup>st</sup> century that advocate for Flexibility to accommodate the changing nature of work and help people to understand and adapt to new technologies, new work environments, and new types of jobs, Lifelong learning by providing up to date skill sets in ones chosen career, Diversity, and inclusion by addressing the challenges faced by people from diverse backgrounds, including those from marginalized communities, Entrepreneurship by supporting people who want to start their businesses and digital literacy by helping people develop digital literacy skill. Therefore, addressing the needs of the 21<sup>st</sup> century calls for being proactive, flexible, and responsive to the changing needs of the workforce to help individuals develop the skills, knowledge, and networks they need to thrive in the rapidly evolving world of work (Haug & Mork, 2021). A case in point, research by (Abdellah et al., 2019) heavily relied on scientific methods developed at universities under controlled conditions, assuming a constant environment, instead of informing students of all the risks involved in all occupations, especially the ever-changing technological needs.

Timely provision of CG is very key if students are to benefit from CG. (Alimam et al., 2014) proposed a recommendation system that allows the

construction of students' profiles based on their aspects of personalization and reflection in learning. Furthermore, the recommendation system based its decisions on the CGPA for final year students as they transit to University. This review established that this research was only based on the Moroccan education system whose findings and recommendations may not be applied to the rest of the world. It should further be noted that providing CG to the student as they transit to University is very late to help them make an informed decision. If a student already chose the wrong combination, they may not be able to get into their desired university program. Also basing on CGPA only to make a career decision may be misleading because it ignores other important factors like interests and update skills that are needed to make an informed career decision (Falco & Summers, 2019). Another related study was by (Startseva et al., 2019) who provided university applicants with an ontology rules application for sensible career choices along the path from secondary to tertiary education, starting with their first important life decision regarding their field of study.

This review further established that there is a separation between educational and training information from job information sources which can lead to mismatched skills, limited job opportunities, inadequate career preparation, reduced job satisfaction, and reduced economic growth. This was evidenced in the research by (Majid et al., 2021), (Dascalu et al., 2022), and (Ibrahim et al., 2019) who did not demonstrate the need for involving all stakeholders in the designing of the proposed recommendation systems. Lack of user participation in developing ontology models can lead to inaccurate or incomplete models, limited domain coverage, difficulty in model adoption, reduced stakeholder engagement, and limited domain applicability. This forms the basis on which this research proposes end-users and stakeholders' involvement in the ontology development process to create models that are accurate, complete, and relevant to the domain they represent. This can be achieved by adopting participatory approaches and user-centred design approaches which advocate for designing with users as opposed to designing for users (Cvitanovic et al., 2019). This would involve integrating all key stakeholders to provide educational and training information with job



information sources to provide individuals with accurate and up-to-date information to make informed decisions about their careers. Involving users in the design also makes the final users accountable, hence increasing their acceptability of the final product (Harrington et al., 2019).

(Dascalu et al., 2022) developed an ontology for educational and career profiling based on the Romanian occupation classification. The study focused on creating smart platforms or recommender systems that would offer personalized educational and professional counseling by recommending jobs to students based on their interests and profiles. Although considering personal interests is an important factor in deciding someone's career decision, it should, however, be noted that it should not be the only consideration due to the potential risks and dangers that this may cause like limited job opportunities, financial instability, burnout, unrealistic expectations and lack of fulfillment. This, therefore, explains why this research proposes an OBM that will take into account job availability, financial stability, and realistic expectations. By considering all these factors, one can be assured of making a more informed decision hence increasing the chances of a successful and fulfilling career as opposed to only considering someone's interests and passion.

Research (Bakke & Hooley, 2022) titled Mapping the Future of Undergraduate Career advocated for Integrated career assistance as a method of providing career help by making use of digital technologies like ontologies, in-person encounters, and any other strategies that are beneficial to students, like the distribution of printed materials. However using this approach would lead to the fragmentation of career information due to a lack of coordination leading to inaccurate or conflicting information, a lack of comprehensive understanding, missed opportunities, and inefficient decision-making. For CG to be meaningful, beneficiaries should be empowered with comprehensive, accurate, and up-to-date career information to help them make informed decisions about their career paths (Keshf & Khanum, 2021).

## CONCLUSION

The field of career guidance is vast and intricate. If the CG sector is to be understood by its intended beneficiaries, there is an urgent need to

reconcile the massive amounts of unstructured data that exist and are being accessed through parallel and uncoordinated means. To handle the difficulties encountered while employing conventional methods like face-to-face meetings, and career guidance, like any advanced profession, requires current solutions. Although some ICT tools, such as websites and recommendation systems, have made an effort to enhance the delivery and access to career information, this review has established that none of the suggested solutions offers a one-stop center for career information that offers enough information to help some people make informed decisions. It has also been proven that the majority of the solutions put out do not address the demands of the 21<sup>st</sup> century, which advocates for digital literacy, soft skills, lifelong learning, global awareness, sustainability, entrepreneurial attitude, and emotional intelligence. A one-stop career information hub based on an ontology model will help deliver comprehensive and structured career information, improve career decision-making, assist effective job search by reducing skills mismatch, boost career growth, and expand accessibility. This can be accomplished by creating an ontology-based model using participatory methods and user-centred designs to organize all career counseling data and prioritize the needs of the twenty-first-century world of work. In the long run, this will increase job satisfaction and productivity since it will allow people, particularly students to make informed career decisions.

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