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COMPUTER-ASSISTED CAREER GUIDANCE TOOLS FOR STUDENTS' CAREER PATH PLANNING: A REVIEW OF ENABLING TECHNOLOGIES AND APPLICATIONS

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ABSTRACT

Aim/Purpose	This study aims to investigate the enabling technologies and applications of computer-assisted career guidance (CACG) tools in the career planning activities of students.
Background	The choice of a career is an extremely significant lifetime decision for any individual. Students often struggle with their career choices mainly due to the lack of awareness in career planning and development. Therefore, students require the support of career counselors for proper career decision-making. Unfortunately, adequate career counseling resources are not readily available within educational institutes. CACG tools offer a workable solution for overcoming this challenge.
Methodology	A systematic literature review was conducted based on a standard guideline for the period of 2011 through 2023. Initially, a comprehensive review protocol was defined and evaluated. In conducting the review, nine electronic databases: Scopus, Web of Science, IEEE Xplore, ACM Digital Library, Science Direct, SpringerLink, Wiley Online, Emerald Insight, and Sage Journals were queried.

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	Then search results were narrowed down to 46 scholarly articles by applying predefined selection criteria.
Contribution	This review study contributes to assessing the status of the existing body of knowledge on implementing and applying CACG tools for career path planning within the education domain. Significantly, this study identified a set of underlying technologies used in implementing modern CACG tools as well as a distinct set of parameters associated with users that can be used as input for offering personalized career decision support. Further, specific needs of applying CACG tools at distinct educational stages were assessed. Study outcomes support future research works by unraveling potential research directions based on identified research gaps.
Findings	The key findings of this study revealed experimentation with a wide range of enabling technologies and techniques in the implementation of CACG tools for students' career path planning. Within these tools, a distinct set of parameters associated with students has been considered as input for offering personalized career decision support. Further, it was found that the use of CACG tools in career guidance differs across distinct educational stages.
Recommendations for Practitioners	CACG has been extensively used within the education domain for providing career guidance services to different student populations. With technological advancements, CACG has evolved as a viable alternative to in-person career counseling, rather than primarily serving as a supplementary tool used by career counselors during in-person counseling. Therefore, it is recommended that educational institutes utilize CACG tools in situations where adequate in-person career counseling services are not possible.
Recommendations for Researchers	Continuous technological advancements make it advisable for researchers to continue further experimentation employing emerging cutting-edge technologies for improving the functionalities of CACG tools used in education. Particularly significant are improvements in personalization capabilities and integrating user profiling techniques to enhance the effectiveness of the services offered by CACG tools.
Impact on Society	Technology-assisted career counseling can play a vital role in fulfilling the career guidance requirements of various student populations. This study has affirmed the potential of using CACG as a viable alternative to in-person career counseling within educational institutes.
Future Research	In future work, the scope of this study can be extended to other educational guidance domains such as academic advising, pedagogical resource recommendation, academic program and course recommendation, and college and university recommendation. Moreover, future research may investigate the application of CACG tools in the career guidance activities of vocational education.

Keywords	computer-assisted career guidance, career planning, career counseling, career guidance, education, systematic literature review

INTRODUCTION

Life is all about making the correct decision at the right time. An individual is compelled to make numerous decisions every single day. Some of these decisions are crucial and might only be made once in a lifetime. Ramifications of such decisions can last for years or even decades. For a young individual, the choice of a career is one such extremely significant life decision. Since one's career is one of

the key aspects affecting success in life, any career-related decision should be taken with utmost attention (Myla et al., 2019; Peker et al., 2017; Shankhdhar et al., 2020; Shi & Shih, 2012; Verma et al., 2017; Waghmode & Jamsandekar, 2016). Thus, career decision-making is a challenging task. Nowadays, students often struggle with making career choices (Alimam et al., 2014; Desnelita et al., 2018; Massoudi et al., 2021; Shi & Shih, 2012; Verma et al., 2017). The lack of awareness in career planning and development, unawareness of personal strengths and weaknesses, and the ambiguity caused due to diversity in individual abilities are a few of the major factors creating career uncertainty among students (Katore et al., 2015; Nazri et al., 2018; Razak et al., 2014; Shankhdhar et al., 2020; Verma et al., 2017). In addition, students are challenged by a highly competitive labor market and the growth and transformation in labor market demand caused by technological advancements (Ade & Deshmukh, 2014; Nazri et al., 2018; Peker et al., 2017; Razak et al., 2014; Shankhdhar et al., 2020; Startseva et al., 2019).

During career planning and development, an individual needs to consider multiple aspects including education, skills, personality traits, personal interest, extra-curricular activities, remuneration, working conditions, workplace culture, and opportunities for career growth (Ade & Deshmukh, 2014; Massoudi et al., 2021; Peiris & Gan, 2013; Qamhieh et al., 2020; Verma et al., 2017; Waghmode & Jamsandekar, 2016). It is undoubtedly challenging for students to determine a favourable career pathway on their own since an in-depth self-evaluation of the aspects previously listed is required (Rangnekar et al., 2018). Accordingly, expert support is vital in proper career decision-making (Mundra et al., 2014; Natividad et al., 2019; Qamhieh et al., 2020). Educational institutions often offer career counseling services that range from individual or group counseling with a focus on self-exploration and job market exploration, to curriculum vitae preparation and job interview skills. However, adequate career counseling services are not readily available to some students due to a lack of qualified career counsellors and resources (Qamhieh et al., 2020). Thus, the unavailability of support for career planning and development increases the possibility that students will make weak career choices (Krishnamurthi & Goyal, 2018; Razak et al., 2014).

Technology-assisted career guidance is a viable alternative for addressing the issue of inadequate career counseling resources within educational institutes (Myla et al., 2019; Peker et al., 2017). The use of computers in career counseling, commonly known as Computer-assisted Career Guidance (CACG), has been in practice since the early 1960s (Copeland et al., 2011; Osborn et al., 2021; Zainudin et al., 2020). Early CACG systems were focused on supplementing in-person career counseling and effective outcomes have been obtained when CACG systems are used in conjunction with in-person career counseling techniques (Copeland et al., 2011; Osborn et al., 2014). With the recent advancement in technology, the capabilities of CACG systems have grown exponentially (Copeland et al., 2011). Modern state-of-the-art CACG systems are built on cutting-edge technologies and accessed online over the Internet (Osborn et al., 2021). These modern systems are designed to support a more self-directed intervention for career exploration and decision-making eliminating the need for in-person career counseling (Urdzina-Merca & Dislere, 2018). In general, the effective use of modern CACG tools within secondary or tertiary education can empower students to make well-informed decisions to better align their academic path toward career goals.

With the widespread use of CACG tools, a decent amount of research has been conducted over the years. Secondary research studies have summarised, synthesised and critiqued existing works. These studies are mostly interdisciplinary and span multiple areas such as career development, technology, education, psychology, etc. However, the number of studies focusing on technologies and applications of CACG tools in education was found to be limited.

This paper investigates the enabling technologies and applications of computer-assisted career guidance (CACG) tools in the career planning activities of students through a systematic literature review. The study has four specific objectives; to investigate research interest towards developing CACG tools for education; to identify enabling technologies for implementing CACG tools; to determine user profiling parameters of CACG tools for personalization; and to assess the application of CACG

tools at distinct educational stages. The outcomes of this study support future research by unravelling potential research directions based on identified research gaps.

The next sections of this paper are as follows. The second section provides a brief overview of career guidance initiatives in education, the role of technology in career guidance, and related research works. The third section presents the research methodology applied in performing the systematic literature review. The fourth section presents results and discusses their implications, identifies limitations of the study, and provides recommendations. The final section concludes the paper with directives for future work.

BACKGROUND AND RELATED WORK

CAREER COUNSELING AND GUIDANCE

Career planning and development is a lifelong process that commences in youth and continues until the age of retirement (Peiris & Gan, 2013). Career planning is the process of setting individual career goals and working out a career development plan for achieving those goals (Shi & Shih, 2012). Career planning requires a rigorous analysis of many characteristics including skills, knowledge, personal qualities, preferences, and motivation. Career development is the continuous process of tracking the progress made in executing a career development plan. Generally, career management includes all aspects of an individual's career planning and development. Career planning and development is a complicated task, and the assistance of an expert is always helpful for beginners.

Career counseling or career guidance encompasses the tasks of assisting an individual with career planning and development. Although the terms "career counseling" and "career guidance" are often used interchangeably, they have distinct meanings and purposes. Career counseling is the process of assisting individuals in exploring, understanding, and making informed decisions about their career path. It is a more personalized, in-depth, and human-centered process that requires the involvement of professional career counselors or career advisors. In contrast, career guidance is a much broader and self-directed process that offers information and resources to support individuals in exploring career options and making informed decisions with the aid of various tools or platforms.

CAREER COUNSELING IN EDUCATION

The education sector of a country plays a pivotal role in meeting labor force demand. Since the economic growth of the country is dependent on its human capital, effective responsiveness of the education sector to workforce and industry demands is crucial. Educational institutions should ensure that students receive the necessary resources and assistance required to make informed career decisions. Thus, the availability of adequate career counseling or career guidance services within secondary and tertiary education will support students in proper career decision-making. Further, this facilitates a smooth and successful transition from education to the workforce (Peiris & Gan, 2013). Thus, career planning and development need to be integral components of secondary and tertiary education to support students in their journey towards achieving their career goals.

The career planning process of students should start at an early age (Haji et al., 2014; Shi & Shih, 2012; Sripath Roy et al., 2018; Verma et al., 2017). Early awareness of different career paths enables students to have a better understanding of possible career trajectories and their requisite requirements (Chandra Prakash et al., 2017). Subsequently, students can tailor their academic journey towards their preferred career path, positioning themselves to 'stand out' in a competitive job market. More specifically, they can select a specialization or combine subjects in high school, college, or university that support progression in their preferred career path (Shi & Shih, 2012). This aids students in acquiring required skills and avoiding industry skills mismatch (Kamal et al., 2021). Subsequently, recent graduates will possess the required knowledge and necessary skills to begin a career in the desired industry without anxiety.

Unfortunately, some students do not have the provisions necessary for obtaining the personalised services of a qualified career counselor. Therefore, during the period of career decision-making, they must rely on the opinions of their parents, friends, relatives, teachers, and senior students (Kamal et al., 2021; Qamhieh et al., 2020). As the opinions of the above-mentioned individuals are mostly subjective, there is a great chance of a student ending up with an inappropriate career choice (Razak et al., 2014; Shankhdhar et al., 2020). This is a very common problem faced by students, especially in developing countries (Qamhieh et al., 2020; Supriyanto et al., 2019). This situation often results in social and economic issues such as high student dropout rates, industry skills mismatch of graduates, increased unskilled workforce, high unemployment rates, high job mobility, and low mental well-being of employees (Haji et al., 2014; Kamal et al., 2021; Rangnekar et al., 2018).

Technology in Career Counselling

With the widespread use of technology in most every field, the potential of technology to deliver enhanced career counseling services has been well recognized by professionals and researchers for years (Vuorinen et al., 2011). Although the use of computer systems in career counseling began in the early stages of computer development, widespread global use was only realized when a few major technological breakthroughs occurred (Maze & Cummings, 1982). In the early years, CACG systems were the most comprehensive technological tool available to career counseling professionals (Copeland et al., 2011). These systems showed greater effectiveness when used along with other traditional in-person career interventions and psychological counseling techniques (Copeland et al., 2011). The capabilities of early CACG systems expanded to cover guidance functions such as self-assessment, planning, and decision-making in addition to occupational information retrieval (Maze & Cummings, 1982; Muroyama, 2004).

Most of the pioneering work on developing early CACG systems happened in North America in the late 1960s to 1970s (Pierce-Price, 1987; Watts, 1986). One of the earliest CACG systems, Information System for Vocational Decisions (ISVD), was developed in the 1960s (Maze & Cummings, 1982). Guidance Information System (GIS), Education and Career Exploration System (ECES), Computerized Vocational Information System (CVIS), Career Information System (CIS), System of Interactive Guidance and Information (SIGI), Coordinated Occupational Information Network (COIN), Computerized Heuristic Occupational Information and Career Exploration System (CHOICES), DISCOVER and PROSPECTS are a few of the popular early era CACG systems (Maze & Cummings, 1982; Muroyama, 2004; Pierce-Price, 1987). Most of these early CACG systems were designed to run on mainframe computers (Pierce-Price, 1987).

Advancements in technology coupled with the widespread use of the Internet paved the way to extend and diversify the application of technology in career counseling services. At present, technology-assisted career counseling has evolved as a viable alternative to in-person career counselling, rather than simply serving as supplementary tool used by career counselors during in-person counseling (Zainudin et al., 2020). While traditional in-person counseling services have expanded online as online chatrooms, online support groups or online video conferencing sessions; the capabilities of CACG systems have scaled up to web-based systems, mobile applications, and social media platforms (Fusco et al., 2020; Zainudin et al., 2020). These state-of-the-art CACG systems can be implemented in different system architectures including expert systems, decision support systems, recommender systems, virtual assistants, and gamified career exploration platforms providing a comprehensive and sophisticated intervention toolset for career exploration and career decision-making.

In general, CACG systems assist the user's career planning and development process by improving self-awareness, increasing knowledge of occupational information, enhancing decision-making skills, improving self-efficacy and confidence in career decision-making, and reducing career decision-making difficulties (Osborn et al., 2021). While in-person career counseling and interventions are still irreplaceable, technology-assisted career counseling initiatives offer effective and convenient means of

career planning and decision-making interventions for coping with highly dynamic and unpredictable labor markets (Leung, 2022).

Related Works

Over the years a fair amount of research has been conducted on CACG due to its wide application in the domain of career counselling. CACG is an interdisciplinary research area that spans multiple domains such as career development, technology, education, and psychology. This section presents the findings of an analysis conducted on existing secondary research focusing on technology-assisted career guidance. Even with an apparent interest in conducting empirical research employing CACG tools, the analysis of existing literature revealed a scarcity in secondary research focusing on technology-assisted career guidance. Appendix A summarizes the purpose and key findings of identified related systematic review studies. Each of these studies has a distinct purpose and some share similar intentions. After an in-depth analysis of related research studies, a few areas of focus could be identified.

The foremost area of focus was evaluating the use of technology in career counselling based on effectiveness and impact. Muhammad (2023) evaluated the effectiveness of using AI in career counselling and Parola et al. (2023) evaluated the effectiveness of using digital games for career development. Significantly, findings of both studies reported positive outcomes based on empirical evidence. Further, Fowkes and McWhirter (2007) point out that CACG systems have been subjected to relatively little empirical outcome-based research. In addition, multiple shortcomings in the existing literature on evaluating effectiveness of using CACG systems in education along with some barriers for conducting outcome research in an education setting have been identified. Moreover Supriyanto et al. (2019) explored the impact of using career guidance expert systems and found favorable support for students in determining and harmonizing the choice of academic majors within their career choices.

The second area of focus evidenced in the literature was assessing benefits and barriers of using technology in career counselling. Uninterrupted and seamless access to services, real-time feedback, multimedia interaction capabilities, and up-to-date information are some of the benefits of applying technology in career counseling (Zainudin et al., 2020). Barriers identified included limited access to the internet, digital illiteracy, lack of awareness, low quality of information, self-limited thinking, confidentiality of data, and limited multi-lingual (Muhammad, 2023; Zainudin et al., 2020).

Other studies focused on assessing underlying technological implementations of CACG systems. Gunwant (2022) evaluated expert systems designed to provide career guidance to students at various educational levels based on technical implementation. Here existing career guidance expert systems have been demarcated into three types namely: rule-based, case-based, and fuzzy logic-based based. In addition, Kalungi et al. (2023) focused on determining the degree to which ontologies have been applied in the career guidance domain.

Limited efforts, however, have been made in assessing the underlying technological implementations of CACG systems. For instance, Gunwant (2022) is restricted to expert systems and excludes alternative forms of CACG tools such as decision support systems, and recommender systems. Kalungi et al. (2023) does not focus on implementation of ontology, but rather assesses the status and need of developing ontology-based systems. These studies lack an in-depth analysis of underlying technologies and techniques used in implementing existing state-of the-art CACG tools. State-of the-art CACG tools offer sophisticated features such as personalization, accessibility, interactivity, real-time updates, data-driven insights, and scalability. Personalization, in particular, is a key functionality of CACG systems as it enables tailored career guidance services to users. Interestingly, none of the related studies focused on assessing existing user profiling approaches, the foundation for personalization.

Fowkes and McWhirter (2007) focused on middle and secondary student populations. While other studies targeted students in general (Gunwant, 2022; Kalungi et al., 2023; Muhammad, 2023; Parola

et al., 2023; Supriyanto et al., 2019). Usually, students at different educational stages have different requirements for career guidance. However, none of the related studies concentrated on examining the applications of CACG tools on distinct student populations across different educational stages.

Overall, the analysis of related literature reveals research gaps in the study of CACG tools, most notably in aspects of underlying technological implementation and application among distinct student groups across different educational stages. Hence this study is focused on addressing this gap by conducting a systematic literature review that includes scholarly articles published in the last 12 years. It is noteworthy that the scope of this study does not include employment or job recommender systems. Employment selection is a significant step for students after completing their education. However, this study is focused on career path planning, rather than career selection after graduation.

METHODOLOGY

Performing a systematic literature review involves a structured and comprehensive approach to identify, select, and synthesize relevant research studies on a particular topic. Although there is no single universally accepted set of standard guidelines for performing systematic literature reviews, efforts have been made to develop guidelines tailored to specific fields or domains. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), Cochrane Handbook for Systematic Reviews of Interventions, and Kitchenham's frameworks are such widely adopted guidelines. PRISMA is a guideline primarily used for reporting systematic reviews and meta-analyses in various fields, particularly in healthcare and biomedical research. It provides a checklist and flow diagram to facilitate transparent and complete reporting of these types of studies (Parola et al., 2023). The Cochrane Handbook provides detailed guidance on conducting systematic reviews and meta-analyses in the healthcare domain (Higgins & Green, 2008). Kichenham's guidelines are specifically designed for conducting systematic literature reviews in software engineering and related fields (Kitchenham & Charters, 2007).

As this study is closely aligned to the field of computer science, the research methodology was developed based on Kichenham's guidelines. Figure 1 illustrates the main steps performed during this systematic literature review. As the initial step, a comprehensive review protocol specifying the procedure used to conduct a systematic review was defined. A well-defined protocol helps reduce the possibility of researcher bias. The key components of the review protocol include needs analysis, research question specification, search strategy (search terms, strings, and sources), study selection criteria and procedures (inclusion and exclusion criteria), a data extraction strategy (how data is recorded and stored) and a data synthesis strategy (how data is summarized and interpreted). The review protocol was evaluated using a set of pre-selected studies relevant to the study scope. The pre-selected studies were tested against the results of the study search strategy and selection criteria to refine the review protocol. The review was then conducted in accordance to the finalized review protocol. In the following sub-sections, the main steps of the review study are discussed.

RESEARCH QUESTIONS SPECIFICATION

Specification of the research questions is the most significant step of any systematic review. These questions set the direction of the systematic review methodology. Therefore, it is necessary to define clear and concise research questions such that they encompass the overall objective of the study. Table 1 contains the research questions that this study aims to answer along with the rationale for formulating the questions.

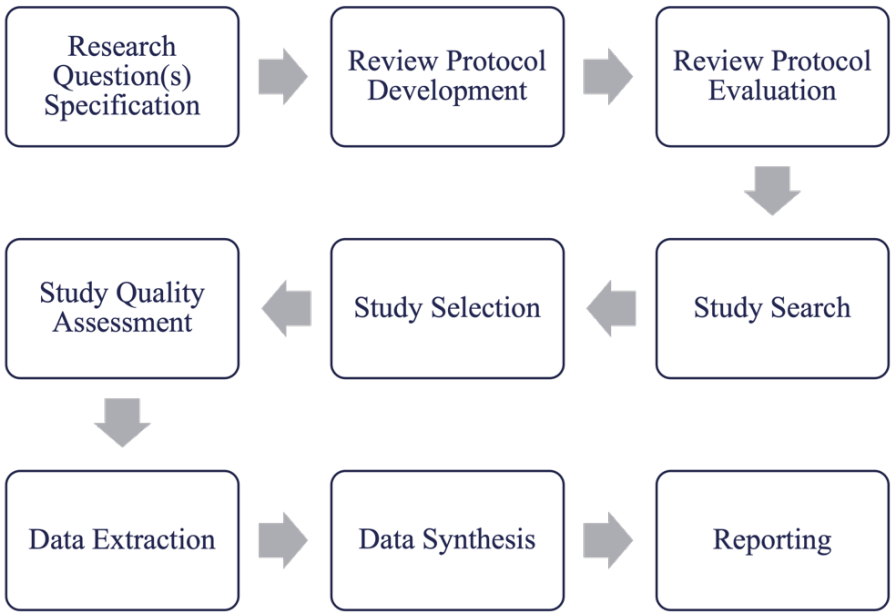

Figure 1. Main steps of a systematic literature review study

Table 1. Research questions and rationale

No.	RESEARCH QUESTION	RATIONALE
RQ1	What is the current level of research interest in developing CACG tools for the education domain?	Over the years, much research has been conducted on the development of CACG tools for students. This research question aims to investigate the types of research conducted, the growth rate of publications, and specific publication sources based on the existing literature.
RQ2	What are the enabling technologies used in implementing modern CACG tools?	The underlying technologies and techniques of CACG tools have evolved over the years. This research question aims to identify the key technologies and techniques utilized in implementing modern CACG tools in the education domain.
RQ3	What are the factors used by modern CACG tools for user profiling?	In providing tailored career guidance services CACG tools require robust user profiles. This research question aims to identify the factors or parameters used for user profiling in existing CACG tools.
RQ4	How are CACG tools used for career guidance at different educational levels?	The requisites of career guidance varies depending on the educational stage/ level of the student. This research question aims to investigate the use of CACG tools within distinct educational stages focusing on target user groups and CACG tool functionalities.

STUDY SEARCH

The first step when defining a search strategy is to identify specific search terms. Subsequently, search strings can be developed. In this study, the search string was formulated based on terms related to the areas of career guidance and computer systems. Search terms and search strings are presented in Table 2.

Table 2. Search terms and search string

AREA	SEARCH TERM
Career guidance	Career, Career Pathway, Career Path, Job, Vocation
Computer systems	Computer-assisted, Computer-aided, Guidance System, Counseling System, Advice System, Recommendation System, Recommender System, Decision Support System, Expert System
Search string	("Career*" OR "Job" OR "Vocation") AND ("Computer*" OR "Guidance" OR "Counselling" OR "Advice" OR "Recommend*" OR "Decision Support" OR "Expert")

Sources for the study search incorporated nine electronic databases (Scopus, Web of Science, IEEE Xplore, ACM Digital Library, Science Direct, SpringerLink, Wiley Online, Emerald Insight, and Sage Journals). Here the search string went through syntactic adaptations according to the particularities of each database. Further, a constraint was applied to the search query for retrieving studies published between 2011 and 2022. As a result, a total of 1274 publications were returned from which 812 were from Scopus, 224 from Web of Science, 95 from IEEE Xplore, 8 from ACM Digital Library, 41 from Science Direct, 22 from Springer Link, 37 from Wiley Online, 11 from Emerald Insight, and 24 from Sage Journals. The list of publications retrieved from each digital library was properly catalogued and stored.

STUDY SELECTION

Table 3 presents the study selection criteria. This specifies five exclusion criteria and one inclusion criterion.

Table 3. Study selection criteria

CRITERIA	DESCRIPTION
Exclusion Criterion (EC1)	No abstract is available for the study.
Exclusion Criterion (EC2)	The study is not written in English.
Exclusion Criterion (EC3)	The study is not published as a full paper.
Exclusion Criterion (EC4)	The study is an older version of an already considered study.
Exclusion Criterion (EC5)	The study is not a primary study.
Inclusion Criterion (IC1)	The study discusses a CACG approach within the education domain.

The study selection process was comprised of four sub-steps followed by a study quality assessment step. The process is illustrated in Figure 2. In the first sub-step, duplicate publications were removed. This resulted in 983 publications, which was approximately a 22.8% reduction. In the second sub-step, selection criteria were applied to the title, abstract and keywords of each publication. This resulted in 104 publications, which was approximately an 89.4% reduction. In this step, studies that were unrelated to the subject were excluded and studies that were considered possibly relevant were taken to the next step for further evaluation. In the third sub-step, selection criteria were applied to the full text, resulting in 41 publications, which was approximately a 60.6% reduction. In the fourth sub-step, snowballing conducted using the 41 papers from the previous stage resulted in 69 new papers being selected. Applying the inclusion-exclusion criteria to the metadata fields and to the full text resulted in 14 papers. This left 55 papers for inclusion in the study quality assessment.

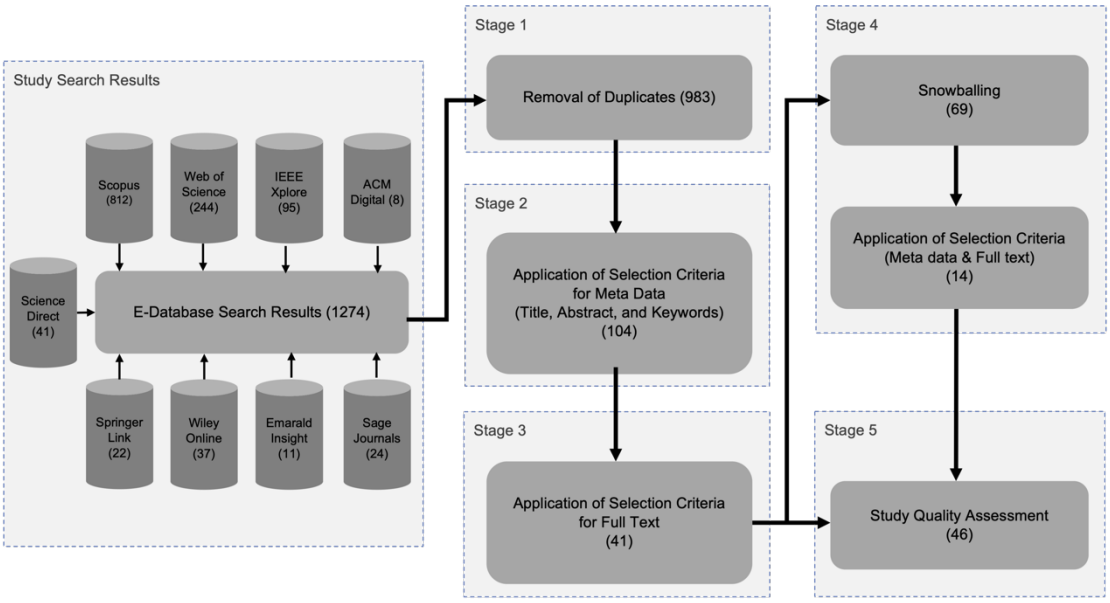

Figure 2. Study selection process

Study Quality Assessment

The quality of the studies selected was assessed based on a quality criterion (QC) containing five questions as presented in Table 4. Each study was numerically rated, and results were evaluated applying Cohen's score for inter-rater agreement. The Delphi method was used to deal with cases of discrepancy between authors. Nine papers were excluded after the quality assessment resulting in 46 articles for final analysis. Appendix B presents the list of bibliographic references of each article along with their unique identifier (#id). These identifiers are used in this paper to refer to their corresponding studies.

Table 4. Quality assessment criteria

CRITERIA	DESCRIPTION
QC1	Are research objectives clearly stated?
QC2	Has the study adequately discussed the background concepts/theories?
QC3	Is the study methodology well-defined?
QC4	Has the study adequately presented results/findings?
QC5	Has an evaluation of results been presented or proposed?

Data Extraction and Synthesis

A Data Extraction Form, designed during the review protocol definition stage, was used with minor improvements to carry out the data extraction process. An electronic spreadsheet was used to store extracted data. The authors of this paper independently partook in the data extraction process. Each study was assessed by at least two authors. All authors assessed any paper for which a discrepancy was identified. Appendix C provides a summary of the characteristics of selected studies.

During data synthesis, extracted data was collated and summarized for each research question. Extracted data was also tabulated in a spreadsheet. Data was aggregated using simple frequency counts and percentages.

RESULTS AND DISCUSSION

This section presents the findings and their implications for each study objective based on the results of the data synthesis stage. Limitations of the study and recommendations are also presented.

RESEARCH INTEREST IN DEVELOPING CACG TOOLS FOR EDUCATION

Over the years, utilization of CACG tools in the education domain has captured significant research interest from researchers, educators, and policymakers. Research in this domain continues to evolve in response to the shifting demands and challenges that occur in the realm of career counseling and education. The field of research focused on CACG tool use is multidisciplinary encompassing disciplines such as psychology, education, technology, sociology, and human resources. As this study aimed to assess the status of the development of CACG tools in education from a technological perspective, only scholarly articles focusing on the technical implementations of CACG tools were considered.

Research interest in a particular domain can be ascertained by focusing on the number of annual publications in the field. Figure 3 illustrates the distribution of publications selected for this study. Research interest in developing CACG tools for education appears to be vibrant and growing. Notably, the number of publications in this area since 2017 remained comparatively high. Scholarly works have been published in journals, conference proceedings, and book sections. Journal and conference publications account for 52% (24 out of 46) and 46% (21 out of 46) respectively. In addition, there was a single book section among the selected articles.

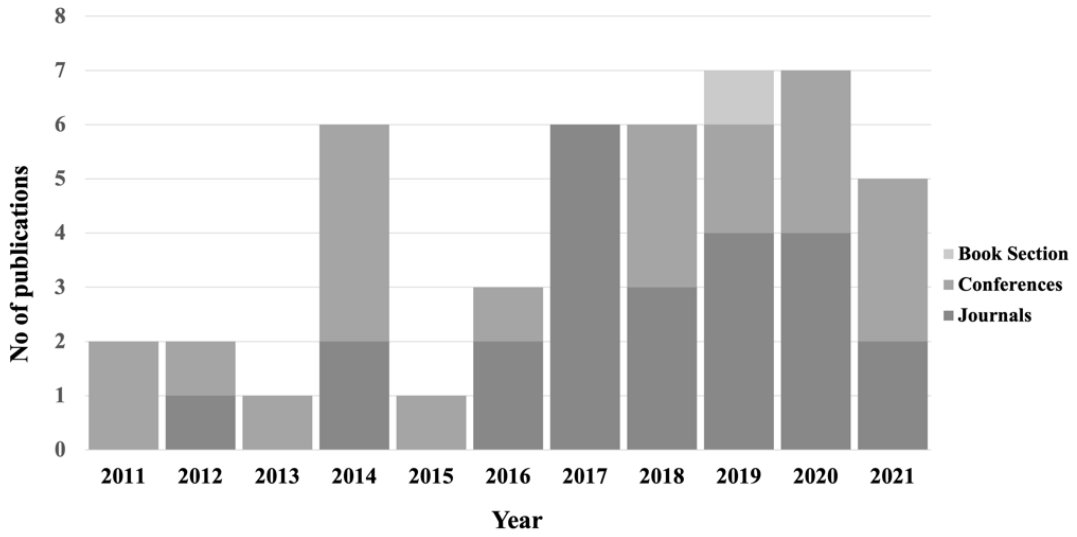

Figure 3. Distribution of the selected publications studies over the years

In general, research studies are categorized into different types based on the nature of the study. Petersen et al. (2008) developed a research study classification that defines six categories including solution proposal, validation research, evaluation research, philosophical papers, opinion papers and experience papers. In a solution proposal, a novel solution or a significantly enhanced existing solution to a particular problem is proposed. Solution proposals may also include a proof-of-concept presented using a simple example, a sound argument, or some other means. In contrast, a validation research study proposes a novel solution that has not yet been practically implemented. This type of study is based on a comprehensive methodology such as experimentation, simulation, or prototyping. Evaluation research studies discuss the practical implementation of a novel or existing technique assessing the technique in terms of benefits and drawbacks. Novelty of the technique is not a requirement of evaluation research. Philosophical research organizes the field using a taxonomy or

conceptual framework to propose novel perspectives on what already exists. Opinion papers convey the writer's personal viewpoint on the merits and drawbacks of a particular method or approach. Opinion papers do not rely on related studies or research methodologies. An experience study describes what and how something has been done in practice and is reported from the perspective of the author's personal experience. The scholarly articles selected for this study fell only under two research types, solution proposal and validation research.

Table 5 presents the distribution of selected studies based on the nature of the research. Validation research studies occur more frequently than solution proposal studies with 30 studies (65%) identified as validation research. The 16 studies (35%) categorized as solutions proposals present conceptual models and methodologies. In these studies, a practical implementation with comprehensive validation had not been completed. But it is worthwhile to point out that three of these 16 studies, namely #10, #13 and #30, discussed some sort of evaluation, albeit, an evaluation that was deemed inadequate to classify these studies as validation research.

Table 5. Distribution of selected studies based on the nature of the research

RESEARCH TYPE	STUDY ID
Solution proposal	#1, #2, #3, #4, #9, #10, #11, #13, #24, #25, #29, #30, #32, #33, #34, #40
Validation research	#5, #6, #7, #8, #12, #14, #15, #16, #17, #18, #19, #20, #21, #22, #23, #26, #27, #28, #31, #35, #36, #37, #38, #39, #41, #42, #43, #44, #45, #46

Enabling Technologies for Implementing CACG Tools

Over the last six decades, CACG systems have evolved from mainframe-based systems to state-of-the-art mobile applications. During this evolution, CACG systems developers utilised enabling technologies and techniques to enhance the capabilities of CACG tools. Modern CACG tools offer extended capabilities that include functionalities such as personalization, accessibility, interactivity, real-time updates, data-driven insights, scalability, and integration. These tools will likely become even more sophisticated as technology advances. Specific technologies or techniques used in implementing CACG tools is generally correlated with intended functionalities, target users, or integrated data sources. The development of these tools often combines multiple technologies or techniques that provide support for comprehensive, user-friendly, and effective platforms.

The purpose of this section is to identify technologies or techniques based on their intended use within a CACG system implementation. Two groups of technologies or techniques were identified within the scope of this study. The first group includes technologies or techniques used in implementing functionalities that enable personalization. The second group includes technologies or techniques for implementing a system architecture that supports functionalities such as user profiling and user interaction. Table 6 presents key technologies and techniques used in implementing functionalities enabling personalization. As shown in Table 6, artificial intelligence-based techniques are extensively utilized in the implementation of personalization capabilities. In addition, multi-criteria decision-making techniques were also identified.

Knowledge-based artificial intelligence (KBAI) is a branch of artificial intelligence which focuses on representing human knowledge and reasoning in a structured way. Among the various reasoning techniques in KBAI, the adoption of rule-based reasoning and fuzzy inference were reported most frequently. In addition, case-based reasoning, model-based reasoning, and ontology-based reasoning were also identified. Rule-based reasoning uses a set of rules to infer new knowledge from existing knowledge. In the selected studies, production rules (#1, #3), forward chaining algorithms (#10, #20), and certainty factor methods (#24, #36) have been incorporated into inference engines. Fuzzy inference uses fuzzy logic to infer new knowledge from existing knowledge. Mamdani (#16, #28, #38, #41) and Fuzzy Associative Memory (#9, #22) methods were the fuzzy inference methods most often cited.

Table 6. Key technologies and techniques used in personalization

TECHNOLOGY	TECHNIQUE	STUDY ID
Knowledge-based Artificial Intelligence (Symbolic AI)	Rule-based reasoning	#1, #3, #10, #11, #13, #20, #24, #31, #36
	Fuzzy inference	#2, #9, #16, #21, #22, #28, #38, #39, #41
	Case-based reasoning	#7, #18
	Model-based reasoning	#17, #32
	Ontology-based reasoning	#30, #34
Machine Learning-based Artificial Intelligence (Machine Learning)	Supervised Learning (classification/ regression)	#6, #7, #12, #14, #15, #19, #23, #26, #29, #33, #35, #38, #40, #42, #43, #44, #46
	Ensemble Learning (classification)	#6, #46
	Unsupervised Learning (clustering)	#25, #42
Multi-criteria decision making	Analytic Hierarchy Process	#21, #34
	Simple Scoring Model	#27

Machine learning-based AI, or Machine Learning (ML) is a subset of artificial intelligence that focuses on developing models that learn from data to make decisions or predictions. Table 7 presents the machine learning techniques and algorithms used to enable personalization. Supervised learning algorithms (classifications and regression) were most frequently reported. Decision Tree and its extended versions: J48, ID3, PRISM, C4.5, XGBoost, and Random Forest are the most often cited classifiers followed by Nearest Neighbours and its extended versions: k-NN, IB1, and K-Star. In addition, Support Vector Machines, Naive Bayes, and Logistic Regression have also been used as classifiers. Studies #6 and #46 implemented the ensemble learning (classification) technique which combines multiple machine learning models to achieve greater accuracy and more robust results. The k-means clustering algorithm is the only unsupervised learning algorithm reported. Additionally, the supervised learning algorithms Stochastic Gradient Descent, Genetic algorithm, Profile and Domain Relevance algorithm were also mentioned.

Table 7. Machine Learning techniques and algorithms used in personalization.

TECHNIQUE	ALGORITHM	STUDY ID
Classification/Regression	Decision Trees (J48, ID3, PRISM, C4.5, XGBoost, Random Forest)	#7, #12, #15, #40, #43, #44, #46
	Nearest Neighbors (k-NN, IB1, K-Star)	#6, #19, #23, #36, #38, #42, #43
	Support Vector Machines	#6, #26, #40, #44
	Naive Bayes	#6, #33
	Logistic Regression	#23
Clustering	K-Means Clustering	#42
Unspecified	Stochastic Gradient Descent	#23
	Genetic algorithm	#5
	Profile and Domain Relevance (P.D.R)	#29

Table 8 presents key technologies or techniques used to implement a system architecture or supportive functionalities of CACG tools. The personalization capability of CACG tools depends significantly on the accuracy of user profiling. The more actively and comprehensively a user engages with a CACG tool, the greater the tool's ability to provide personalized guidance and recommendations. Compared to conventional user profiling techniques (questionnaires or aptitude tests) modern CACG tools leverage techniques such as ontology engineering, social network analysis, and natural language processing to create highly detailed and personalized user profiles, which in turn, enhances the guidance and recommendations provided by the tool.

With the continuous growth of the Internet, web technology provides an ideal infrastructure for the development of CACG tools. Web-based CACG systems are characterised by accessibility, scalability, real-time updates, cross-platform compatibility, personalization, and other features. Mobile technology has further enhanced these capabilities by making access to CACG tools more convenient and flexible. Furthermore, enabling technologies such as gamification, agent technology, robotics, virtual reality and IoT have been used to enhance the user interaction and overall experience with CACG systems.

Table 8. Key technologies used in implementing CACG tools.

TECHNOLOGIES/TECHNIQUES	STUDY ID
Web technology	#2, #5, #9, #16, #20, #25, #33, #36, #42, #46
Mobile technology	#22, #29, #39, #41
Gamification	#4, #17, #32, #37
Ontology Engineering	#8, #11, #25
Social Network Analysis	#21, #23, #29
Natural Language Processing (NLP)	#1, #40
Agent technology	#2, #11
Robotics	#35
Virtual Reality	#37
Internet of Things (IoT)	#45

User Profiling Parameters for Personalization in CACG Tools

In CACG tools, user profiling involves gathering and analyzing user information as a means to provide tailored career advice and recommendations. Information gathering for user profiling can be performed either implicitly or explicitly (Cufoglu, 2014). In the explicit approach, users themselves voluntarily provide information. In the implicit method, the system automatically gathers information by monitoring user interactions. A user profile is typically defined as a set of parameters or attributes that describe a user's characteristics, preferences, and behaviors (Eke et al., 2019). A comprehensive user profile can support a higher level of personalization, whereas the selection of the most relevant and informative set of parameters is crucial for effective results.

During in-person career guidance, counselors use different methods to identify an individual's characteristics such as personality traits, skills, interests, and values. Using this information, counselors assist individuals in setting career goals and selecting suitable career paths. Similarly, CACG tools use a distinct set of user parameters to offer personalized career decision support. This section identifies user profile parameters employed in existing CACG tools employed in the education domain. Table 9 provides a summary of identified user profile parameters. The identified parameters are listed under

seven categories: academic qualifications, professional qualifications, skills, personality, personal preference, extra-curricular achievements, and demographic characteristics.

The most widely cited categories of user profiling included academic qualifications, skills, personality, and personal preference. Academic qualification parameters evaluate an individual's educational background and expertise. Skill parameters refer to the specific abilities, competencies, talents, strengths, and self-potential that an individual possesses. Some studies subdivided skill parameters into technical skills and soft skills. Personality parameters refer to the various traits, characteristics, and attributes that make up an individual's personality. In identifying personality type, some studies adopted standard personality assessment tests such as the Holland model (#8, #30, #34, #39, #45), Myers-Briggs Type Indicator (#13, #23, #41), and RiASEC model (#33). Preference refers to an individual's specific inclinations, interests, and choices regarding a desired career path.

Some studies also considered professional qualifications, extra-curricular achievements, and demographic information. Professional qualification parameters consider vocation-related achievements. Extra-curricular achievements include accomplishments and experiences gained outside of the formal academic curriculum. Demographic parameters include age, gender, hobbies, health, and socio-economic status.

Use of CACG Tools at Distinct Educational Stages

The structure of an educational system can vary from country to country. Generally, an educational system encompasses a set of distinct stages starting from early childhood education and extending to higher education. These stages typically include early childhood education, primary education, secondary education, tertiary, or vocational education. Students in each educational stage may have distinct career guidance requirements such as career awareness, self-exploration, academic planning, career exploration, career assessment, resume building, and interview preparation. To achieve a proper transition from school to work, students should make career-related decisions during, or at least by the end, of their secondary education. Career guidance in secondary education is broad and focuses on helping students explore their interests and prepare for furthering their education or training. In contrast, career guidance in tertiary education is more advanced, specialized, and focused on transitioning into the workforce within a chosen field.

The distribution of studies by target groups and educational stages is shown in Table 10. Among the studies, 26 are focused on secondary-level (high school/ middle school) students or graduates and 13 are focused on tertiary-level (universities, colleges, and institutes) students or graduates. Another 11 studies did not clearly mention a specific target student group or they employed a general focus on students or youth. It is important to note that few studies (#1, #15 and #37) belong to more than one target group.

The number of studies focused on the senior end of the secondary education level is comparatively higher than those that focus on other educational levels. Across the globe, most education systems mandate the selection of a specialized academic stream (such as science, technology, engineering, medicine, arts, commerce etc.) for tertiary education. The main objective of CACG tools is to support the decision-making process of students in selecting the most appropriate academic stream for tertiary education. In addition, some CACG tools provide recommendations related to academic programs (#20, and #39) or higher educational institutions or universities (#25 and #45).

Table 9. Identified user profiling parameters

CATEGORY	PARAMETER	STUDY ID
Academic qualifications	Academic performance records	#8, #10, #27, #30, #33, #38, #45
	Grades/Grade Point Average (GPA)	#7, #8, #16, #17, #28, #32
	Class of the degree	#35
	Scores/Marks in selected subjects	#18, #21, #26, #35, #36, #41
	Field of study/Specialization	#26, #28, #34, #35
	Marks in entrance exam/Aptitude test	#15, #23, #34, #39, #40
	Scores for intelligence quotient (IQ) tests	#7, #15, #20, #29, #43
	Cut off marks for university/college	#34
	Marks in national level exams	#28, #38, #43
Professional qualifications	Courses	#35
	Certifications	#26
	Trainings/workshops	#11, #26
Skills	Skills/abilities/competencies/talents/strengths/self-potential	#1, #3, #4, #5, #7, #9, #10, #11, #12, #14, #20, #21, #24, #25, #27, #36, #42, #44, #46
	Technical skills	#10, #19, #26, #42
	Soft skills	#4, #6, #12, #15, #17, #26, #32, #35, #42, #43
Personality	Personality analysis	#2, #4, #8, #9, #10, #11, #22, #23, #27, #30, #33, #38, #41, #45, #,
	Personality type (Holland model/Myers-Briggs Type Indicator/ RiASEC model)	#8, #13, #23, #30, #33, #34, #39, #41, #45
	Values/qualities	#2, #4, #5, #11
Personal preference	Preference/interest	#1, #2, #3, #4, #5, #10, #11, #15, #16, #19, #20, #24, #25, #26, #27, #28, #29, #31, #33, #36, #40, #41, #44, #46
Extra-curricular achievements		#41
	Competitions/ Sports	#26
Demographic characteristics	Age	#19
	Gender	#7, #11, #23, #41
	Hobbies	#7, #10, #20, #26
	Health/ Socio-economic status	#11

In some countries, the education structure mandates students select an academic stream at an early stage, typically during the junior secondary level. For example, studies #1, #14, and #15 focus on students in India who have completed their junior secondary school (grade 10) where they must choose a stream (art, commerce, or science) for their senior secondary level. Similarly, study #8 targets middle school (grade 9) students in Morocco where they must choose a field for high school. Finally, study #38 focuses on Nigeria where students need to select subjects from a specific area of concentration.

Tertiary education offers specialized knowledge and skills relevant to specific career paths. While some academic programs are explicitly designed to prepare students for specific careers, some offer students the flexibility to select a major area of specialization within an academic stream after they have completed preliminary years of study. For example, study #3 presents computer-assisted approaches for guiding university students in selecting a major or field of study in the undergraduate program. Similarly, study #41 focuses on developing a recommender system for assisting students in selecting an appropriate engineering discipline. Recent graduates or final-year students are concerned with selecting the most suitable career path based on their qualifications. As such, existing CACG tools are focused on providing tailored career guidance to students and supporting students in making informed decisions about their careers.

Table 10. Distribution of studies among target groups and educational stage

EDUCATIONAL STAGE	TARGET GROUP	STUDY ID
Secondary Education (High School/Middle School)	Junior Secondary Students (Grade 9/10)	#1, #8, #14, #15, #38
	Senior Secondary Students (Grade 11/12) or Secondary School Graduates	#1, #7, #10, #15, #16, #18, #20, #21, #22, #23, #25, #28, #30, #31, #36, #37, #39, #42, #43, #45, #46
Tertiary Education (University/College)	Students (Early years)	#3, #34, #37, #41
	Students or Graduates	#2, #4, #9, #17, #24, #26, #27, #32, #35
Unspecified	Students/Youth	#5, #6, #11, #12, #13, #19, #29, #33, #40, #44

LIMITATIONS OF THE REVIEW

The initial work required in the study search related to search string formulation proved to be challenging. This was due to the inherent confusion that arises when defining related terminology that spans various research areas. To resolve this issue, a trial-and-error approach was used based on selecting various combinations of terms. The different combinations were tested by executing queries in selected e-libraries, which lead to iterative improvements in the search string and resulted in the construction of effective search queries. However, there is also a chance that this may have resulted in the exclusion of some relevant articles from this study.

Further during the e-library search, the search query underwent syntactic changes due to each e-libraries' limitations. For example, some libraries had a constraint on the number of terms that could be used in a search query. Therefore, the search string was generalized to widen the search scope to prevent excluding relevant articles.

In addition, concerns of subjectivity arose during the study search and selection step, given that author involvement was not evenly distributed. For example, study search and selection were initially

conducted by only two authors. To overcome this limitation, the same tasks were repeated by the two other authors. Ultimately each study was checked against the selection criteria by at least two authors. Finally, an analysis of the degree of conformance was conducted using the kappa coefficient to measure the level of agreement between authors.

RECOMMENDATIONS

CACG has been extensively used within the education domain to provide career guidance services to different student populations. Technological advancements have made it possible to expand and diversify the use of technology in career counselling services. Thus, CACG has evolved as a viable alternative to in-person career counselling, rather than simply serving as a supplementary tool used by career counselors during in-person counseling. It is recommended that educational institutes utilize the services of CACG tools in situations where adequate in-person career counseling services are not possible.

Recent developments in web-based and mobile technologies have had a transformative effect on the development paradigm of information systems resulting in the implementation of more efficient, flexible, and user-friendly systems. Enabling technologies such as cloud computing, serverless design, microservices, cross-platform development, responsive design, user experience design, API integration, and IoT integration have played a pivotal role in this transformation. Therefore, it is recommended to investigate integrating these technologies into CACG tools employed within the education sector.

Artificial intelligence-based techniques have been extensively utilized in the development of personalization capabilities offered in CACG tools. AI is a dynamic and rapidly advancing field with new developments constantly occurring. Further investigation into how the means and methods of AI can be utilized to further enhance personalization capabilities in CACG tools is recommended.

The degree of personalization depends on the comprehensiveness of the user profile. Novel user profiling techniques are beginning to leverage evolving technologies such as social network analysis, natural language processing, virtual reality, Internet of Things, and robotics. The effectiveness of these novel techniques extends career guidance and counselling well beyond conventional self-administered survey techniques. Hence, investigating approaches that facilitate the integration of advanced user profiling techniques into CACG tools is recommended.

A variety of CACG tools has been developed and implemented across various educational stages to address the distinct career guidance needs of students. For continuous and seamless career guidance support, efforts should be made to implement a universal platform that caters to many different student populations. While the core functions of CACG tools remain similar across groups, specific features can be tailored to better meet the needs and challenges of different student populations.

CONCLUSION

Career guidance is a vital component of education that supports students in making informed decisions about their future education and employment. A lack of career counselors and other resources within educational institutions can lead to negative consequences. The use of CACG is a viable alternative to ensure the availability of sufficient career guidance services to students. With recent advancements in technology, the capabilities of CACG systems have grown exponentially. These modern systems are designed to support more self-directed interventions for career exploration and decision-making reducing a reliance on in-person career counseling. This study provides a significant contribution by attempting to address gaps identified in the existing literature related to CACG implementation and effectiveness.

This study first investigated the research interest related to the development of CACG tools for deployment in education. Recent publication statistics revealed that research interest is vibrant and

growing. The research domain of career guidance is driven by several factors including fast-evolving labor markets, increasing complexity in career choices, increasing demand for personalized career guidance, and continuous technological advancements. Additionally, this study identified a set of underlying technologies employed in the implementation of modern CACG tools and experimentation with a wide range of enabling technologies and techniques has occurred in the development of CACG tools. Notably, artificial intelligence-based techniques are extensively utilized in implementing personalization capabilities. Other enabling technologies such as web technology, mobile technology, gamification, agent technology, robotics, virtual reality, and IoT have been used to enhance user interaction and overall system architecture. This study also identified a distinct set of user parameters that can be used as inputs to offer personalized career decision support. Among these parameters, academic qualifications, skills, personality, and personal preference are most widely used. Finally, this study evaluated specific requirements for implementing CACG tools at distinct educational stages. Career guidance in secondary education is broad and focuses on helping students explore their career interests and prepare for further education or training. In contrast, career guidance in tertiary education offers specialized knowledge and skills relevant to specific career paths. Hence functionalities and services offered by CACG tools are often correlated to a target student population.

Considering its wide application and positive outcomes, CACG can be recommended as a feasible alternative for in-person career counseling within educational institutions. Further, it is advised to carry out extended research on the integration of emerging cutting-edge technologies within CACG tools targeting the education domain. Specifically enhancing personalization capabilities through recent developments in AI and utilizing advanced user profiling techniques are recommended areas of research focus. The scope of this study restricted the study selection to studies focusing on career path planning and guidance in the education domain. In future work, the scope of this study can be extended to other educational guidance domains such as academic advising, pedagogical resource recommendations, academic program and course recommendations, and college and university recommendations. This study was confined mostly to secondary and tertiary education. Future research may investigate the status of the application of CACG tools in the career guidance activities of vocational education.

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APPENDIX A: SUMMARY OF RELATED STUDIES

STUDY	PURPOSE	KEY FINDINGS
(Muhammad, 2023)	To review empirical data on career counseling with Artificial Intelligence (AI) in two areas: barriers and effectiveness.	Studies that have investigated the obstacles surrounding the utilization of AI in the domain of career counseling are found to be limited. Among identified obstacles, lack of stable Internet connectivity and multi-lingual support takes a major place. Referring to empirical evidence, AI-driven career counseling has indicated successful outcomes.
(Kalungi et al., 2023)	To determine the degree to which ontologies have been applied in the career guidance domain.	Existing empirical studies do not provide an all-inclusive platform for career information that offers sufficient information to make informed decisions. Findings emphasized that ontologies enable the delivery of career guidance services by providing a structured form to represent and organize career-related data.
(Parola et al., 2023)	To review the literature concerning the application of digital games for career development in career guidance settings.	Findings signify a positive effect of digital games on career development highlighted by the increase in motivation and interest in career exploration. Studies based on solid theoretical foundations relating to game-based career guidance are found to be limited.
(Gunwant, 2022)	To review expert systems designed for providing career guidance to students at various levels of education based on technical implementation.	Based on technical implementation, 3 types of career guidance expert systems (rule-based, case-based, and fuzzy logic-based) have been identified along with key features. Rule-based expert systems were found to be the most popular due to ease of development. Game-based systems were identified as an emerging type of CACG expert systems.
(Zainudin et al., 2020)	To review the status, benefits, and challenges of technology-assisted career counseling.	Existing literature has evidenced current trends toward using technology in career counseling. Uninterrupted and seamless access to services, real-time feedback, multimedia interaction capabilities, and up-to-date information have been identified as benefits of applying technology. Lack of awareness, limited access to the internet, digital illiteracy, low quality of information, self-limited thinking, confidentiality of data, and urgent client requirements have been identified as challenges.

STUDY	PURPOSE	KEY FINDINGS
(Supriyanto et al., 2019)	To review the impact of the application of expert systems in student guidance and career guidance.	The impact of expert systems in career guidance has been assessed based on two applications: the selection of academic majors and the selection of a career. The outcomes of the study emphasize that the application of expert systems in career guidance greatly assists students in determining and harmonizing the choice of academic majors with their career choices. Encourages extended research work on sustainable development of expert systems to counter the aspects of uncertainty arising from applications and user factors.
(Fowkes & McWhirter, 2007)	To review the status and obstacles of research evaluating the effectiveness of the use of CACG systems for middle and secondary student populations.	CACG systems are found to be subjected to relatively little empirical outcome research and suggest further research. Existing literature on the effectiveness of using CACG systems has multiple weaknesses including focusing on user satisfaction rather than career-related gains; failure to examine potential differential effects of CACG systems associated with gender, ethnicity, or socioeconomic status; and reliance on small convenience data samples. Lack of models for CACG systems evaluation, rapid changes in technology, and the flexible nature of system usage have been identified as obstacles to conducting outcome-based research in education settings.

APPENDIX B: UNIQUE IDENTIFIER FOR SELECTED STUDIES

PAPER ID	UNIQUE IDENTIFIER FOR SELECTED STUDIES
#1	(Srivathsan et al., 2011)
#2	(Cao & Zhang, 2011)
#3	(Al Ahmar, 2012)
#4	(Shi & Shih, 2012)
#5	(Peiris & Gan, 2013)
#6	(Ade & Deshmukh, 2014)
#7	(Nawaz et al., 2014)
#8	(Alimam et al., 2014)
#9	(Razak et al., 2014)
#10	(Mundra et al., 2014)
#11	(Haji et al., 2014)
#12	(Katore et al., 2015)
#13	(Iwayemi et al., 2016)
#14	(Sodhi et al., 2016)
#15	(Waghmode & Jamsandekar, 2016)
#16	(Peker et al., 2017)
#17	(Chandra Prakash et al., 2017)
#18	(Ezenkwu et al., 2017)
#19	(Ansari, 2017)
#20	(Alao Kazeem et al., 2017)
#21	(Verma et al., 2017)
#22	(Krishnamurthi & Goyal, 2018)
#23	(Rangnekar et al., 2018)
#24	(Desnelita et al., 2018)
#25	(Obeid et al., 2018)
#26	(Sripath Roy et al., 2018)
#27	(Nazri et al., 2018)
#28	(Natividad et al., 2019)
#29	(Talke et al., 2019)
#30	(Abdellah et al., 2019)
#31	(Myla et al., 2019)

PAPER ID	UNIQUE IDENTIFIER FOR SELECTED STUDIES
#32	(Prakash et al., 2019)
#33	(Cruz et al., 2019)
#34	(Startseva et al., 2019)
#35	(Mithsara et al., 2020)
#36	(Nunsina et al., 2020)
#37	(Prokhorov et al., 2020)
#38	(Awoyelu et al., 2020)
#39	(Comendador et al., 2020)
#40	(Joshi et al., 2020)
#41	(Qamhieh et al., 2020)
#42	(Vignesh et al., 2021)
#43	(Mejia et al., 2021)
#44	(Massoudi et al., 2021)
#45	(El Mrabet & Ait Moussa, 2021)
#46	(Kamal et al., 2021)

APPENDIX C: CHARACTERISTICS OF SELECTED STUDIES

ID	YEAR	TARGET GROUP	PURPOSE	SUMMARY OF FINDINGS
#1	2011	Secondary School Students (After 10 & 12 Grade Examination)	To develop a question-and-answer-based system to provide students with career counseling.	A conceptual design of a career counseling expert system has been proposed using Natural Language Processing.
#2	2011	College Students	To develop a web-based expert system thatprovides advice after appropriate diagnosis of occupational problems of its users.	A system architecture of an expert system based on agent technology and fuzzy logic uncertainty reasoning method has been proposed.
#3	2012	University Undergraduates	To develop a rule-based expert system for guiding university students in selecting suitable undergraduate university majors.	A prototype of an expert system for university major selection has been implemented.
#4	2012	College Graduates	To assess feasibility and propose possible approaches for developing a game-based career guidance system.	A conceptual design of a game-based career guidance system has been proposed.
#5	2013	Youth (in Emerging Knowledge Economies)	To develop a National Career Pathways Development system (NCPDS) that supports career choices of youth based on national needs.	The proposed NCPDS has been implemented as a prototype hybrid recommender system (collaborative filtering-in, knowledge-based filtering-in, and content filtering-out).
#6	2014	Students of Age Group 16 to 20	To assess the existing incremental machine learning techniques for experimental classification of students considering their career choice.	The proposed ensemble incremental learning algorithm combines Naive Bayes, K-Star, and SVM classifiers using the majority voting rule.
#7	2014	Pre-tertiary Students	To develop an automated system that solves the career assortment problems by making use of case-based reasoning and Decision Tree (J48) algorithms.	An automatic career path recommendation approach has been implemented based on case-based reasoning and J48 decision tree algorithms.
#8	2014	Middle School Students (9th Graders)	To support students in finding a suitable career pathway that matches their abilities and tendencies.	A conceptual career recommendation model has been proposed based on a mathematical model (RCS).

ID	YEAR	TARGET GROUP	PURPOSE	SUMMARY OF FINDINGS
#9	2014	Final Year Students for the Faculty of Computer & Mathematical Sciences	To build a Career Path Selection Recommendation System (CPSRS) that steers students to choose a career based on their skills and abilities.	The proposed CPSRS has been implemented as a web-based recommendation using a fuzzy logic technique.
#10	2014	Pre-tertiary Students	To build a Career Advice Model (CAM) model-based expert system that supports decision-making of students in higher education.	The proposed CAM has been implemented as a rule-based decision support system using machine learning techniques and Java language.
#11	2014	Students	To develop a multi-expert system for educational and career guidance by using a multi-agent approach and the semantic web.	A conceptual design of a web-based multi-expert career guidance system has been proposed using a multi-agent paradigm and ontology.
#12	2015	First Year Engineering Students	To assess the ability of using selected machine learning techniques against c4.5 algorithms for career prediction and recommendation of students.	The C4.5 machine learning algorithm gives better performance compared to Naïve Bayes, K Star, and Simple Cart algorithms.
#13	2016	Children and Youth Exposed to Different Academic Areas	To develop a career-advisor expert system based on the Myer-Briggs Personality Assessment.	A rule-based career-advisor expert system has been implemented using the SWI-Prolog tool.
#14	2014	Secondary School (Grade 10)	To develop a decision support system using an artificial neural network (ANN) for choosing the vocational stream of pursuit based on the student's aptitude.	A four-layer feed-forward ANN-based career decision support system was implemented and evaluated.
#15	2016	Secondary School (Grade 10 and 12)	To design and implement a framework of an expert system for career selection.	A career selection expert system has been implemented using data mining algorithms (Prism, ID3, and IB1).
#16	2017	Final Year of Secondary School	To implement an automated system for vocational guidance of final-year secondary school students.	A web-based recommendation system has been implemented using the Mamdani fuzzy logic technique.
#17	2017	Final Year Undergraduates (B. Tech students)	To develop an expert system that supports the selection of a suitable career by assessing the memory power of a student.	An expert system has been implemented to predict selected job positions in the software engineering sector using a series of psychological tests.

ID	YEAR	TARGET GROUP	PURPOSE	SUMMARY OF FINDINGS
#18	2017	High School Students	To develop an automated career guidance expert system using case-based reasoning technique.	An automated career guidance expert system has been implemented using the case-based reasoning technique.
#19	2017	Scholars	To propose a framework for a multilevel expert system to advise scholars for their future careers.	A data mining-based expert system framework that can advise scholars at different levels has been proposed.
#20	2017	Pre-tertiary Students	To develop a web-based intelligent career guidance system that assists pre-tertiary science students in Nigeria to independently choose a career path.	A web-based expert system was designed and implemented using the rule-based forward chaining algorithm.
#21	2017	Secondary School level (After 12 Grade Examination)	To effectively recommend a career path for students in the engineering stream after the 12 grade examination.	A recommendation system has been implemented as a three-dimensional model (preference, fuzzy logic, and influence) that can recommend career paths by generating a desired score based on the AHP decision process.
#22	2018	Higher Secondary School Students (Grade 12)	To develop a career path recommendation system for students in higher secondary school.	A recommendation system based on Holland code theory and fuzzy-logic technique has been implemented and validated.
#23	2018	Pre-tertiary Students	To develop a career prediction model for selecting an optimum career with personality and aptitude marks.	A career prediction model has been implemented using a linear classification based on aptitude, personality, and background parameters.
#24	2018	College Students	To develop an intelligent decision support system (IDSS) for the students' career selection using the certainty factor method.	The proposed IDSS architecture has been demonstrated using the certainty factor method and expert knowledgebase.
#25	2018	High School graduates	To recommend the appropriate majors and universities for students based on their requirements, interests, preferences, and capabilities.	A conceptual design of an ontology-based recommender system integrated with machine learning techniques has been proposed.
#26	2018	Computer Science Domain Candidates	To develop a career prediction model based on machine learning techniques.	SVM algorithm has the highest accuracy in contrast to the Decision Tree and XG Boost algorithms.

ID	YEAR	TARGET GROUP	PURPOSE	SUMMARY OF FINDINGS
#27	2018	University Undergraduates (Final year)	To develop a career decision support system to guide students in their career planning.	A decision support system has been implemented as a desktop application based on a mathematical multi-criteria model (simple scoring model).
#28	2019	Senior High School Students (Grade 11 and 12)	To develop a fuzzy logic-based recommender system for predicting the career track of students.	A fuzzy logic-based recommendation system has been implemented and evaluated.
#29	2019	Students	To develop a mobile application that can determine and guide students in the most interested career domain effectively.	A conceptual architecture of a three-tier system based on web and mobile technologies along with Profile and Domain Relevance (P.D.R) algorithm has been proposed.
#30	2019	Final Year High School Students	To guide students to the most suitable career track based on labor market trends and student capabilities.	A mathematical model (Science Process Skill) based recommendation approach has been developed and tested.
#31	2019	Pre-tertiary Students	To develop a computer-assisted decision support system for students to select different branches of higher education.	A rule-based decision support system has been implemented to assist students in selecting a suitable academic branch based on interest.
#32	2019	Students (University/Institute)	To predict suitable careers for students based on a cognitive model built using gamification.	A career prediction approach based on a cognitive model (built on psychological factors extracted through a set of games) has been proposed.
#33	2019	Students	To develop an intelligent web platform that helps students to discover their professional interests using data mining.	A conceptual design of a web platform for vocational guidance based on data mining has been proposed.
#34	2019	University Students	To develop an ontology-based decision support system to support a student in choosing a field of study.	A set of decision support rules has been implemented based on a developed domain ontology.
#35	2020	Undergraduates in Computer Science (final year)	To develop a career-guiding robotic companion for university students.	A robotic platform for career guidance has been implemented based on ANN.
#36	2020	High Schools	To assist students in determining their career after graduating from high school.	The proposed approach of combining K-NN and Certainty Factor techniques has given a higher accuracy in career prediction.

ID	YEAR	TARGET GROUP	PURPOSE	SUMMARY OF FINDINGS
#37	2020	New Applicants and First Year Students	To develop a career guidance 3D quest game to estimate the competency of first-year students and new applicants.	A 3D quest game based on virtual reality has been implemented and evaluated.
#38	2020	Junior Secondary Schools	To develop a career path decision making model for junior secondary school students.	A career path decision making model based on fuzzy k-nearest nearest algorithm has been implemented using MATLAB tool.
#39	2020	Senior High School Students	To develop an application that can recommend an appropriate university program to students based on their personality type and knowledge strength.	A mobile application has been implemented and evaluated based on the fuzzy logic technique.
#40	2020	Students	To develop a career counseling system that predicts the best career path for students using artificial intelligence.	A conceptual design of a career counseling system based on chatbot, and machine learning algorithms (Decision trees and Software Vector Machines) has been presented.
#41	2020	High School Students	To support high-school students to choose their educational discipline and career path based on their personal and academic profiles.	A fuzzy logic-based recommendation system has been implemented as a mobile application.
#42	2021	Pre-tertiary Students	To recommend the right career stream based on an objective assessment of one's skill set and caliber.	A web-based career guidance system has been implemented based on machine learning algorithms (KNN and K-Means Clustering).
#43	2021	Senior Students in a Public School (High School Students)	To build a recommendation system based on Gardner's multiple intelligences test using the results of the Saber 11 tests and information on family.	Among the machine learning models (KNN, Decision Trees, and XGBoost) tested during the implementation, XGBoost algorithm has the highest accuracy.
#44	2021	Students	To recommend the most appropriate career path in the computer science area using individual characteristics.	Decision trees based on the information gain algorithm (having a tree depth of 6) have a higher accuracy than the Gini measure method.
#45	2021	Pre-tertiary Students (Secondary School Students)	To build a recommendation system that evaluates students' potential and provides counseling for selecting career paths.	A smart guidance system has been implemented using IoT and mobile technologies.

ID	YEAR	TARGET GROUP	PURPOSE	SUMMARY OF FINDINGS
#46	2021	Students About to Begin Higher Education	To build a career guidance system that can aid the students in choosing the most appropriate career path.	A web-based system has been implemented based on an ensemble algorithm that combines XGBoost and Random Forest classifiers.

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