

Scrutinising Artificial Intelligence based Career Guidance and Counselling Systems: an Appraisal

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Abstract: The proliferation in automation and digitization of work have substantial impact in shaping the nature of career counselling, career development and career choices. With increasing change in occupations, more number of individuals are confronted with acquainting themselves with upcoming industries and occupations. Career experts play a significant role in assisting people to evaluate, obtain and infer these changes while helping them in appropriate career selection and planning. The career guidance and counselling is in its initial stages in India and the conventional manual method being employed proves to be inefficient and ineffective. Automation of career guidance and counselling process with the help of intelligent computer-aided solutions have considerable potential and will be of greater importance. Besides, simplifying task and saving effort as well as time, an automated solution has substantial capability to engage and reach, larger diverse group of people. In this paper, contemplation of numerous Artificial Intelligence (AI) based schemes offered in the field of career guidance and counselling has been performed. This paper begins with prominence of career guidance and counselling followed by scrutinizing the scope of various technologies in contributing a solution. Besides, extensive work performed in this field has been critically surveyed. Ultimately, the challenges and open problems were implications from the conducted survey. The paper identifies directions for potential research in this domain, hoping to drive attention of research community.

Keywords: Artificial Neural Networks, Career Counselling, Career Guidance, Expert System.

I. INTRODUCTION

Numerous challenges are affecting career experiences of youth such as advancement in technology, variations in economy, globalisation, and worldwide competitive-education market. Further, education sector has been confronted with abrupt increase in student diversity and number followed by changing attitudes of youth [1], [2]. At present, the uncertainty among youth regarding their career is a major concern [3]. The selection of suitable career has turned out to be a complex science owing to its diverse disposition [4]. Numerous factors contribute to selection of career which may be extrinsic, intrinsic or combination of the both; making career selection a complicated, time consuming and daunting process. Selection of suitable career is the most important decision in an individuals' life as it affects them financially, socially and psychologically through their lives [5], [6], [7], [8].

According to a survey [9], 50% people out of one lakh fifteen thousand persons considered across thirty-three countries indicated selection of wrong career. Selection of wrong career results in wastage of individuals' potential, resources while degrading the success/sustainability of organizations and eventually hampering growth of a nation [10].

The career development of an individual is predominantly governed by their decision making competence [11]. The students are required to choose career paths mostly when studying in pre-tertiary levels. The students at this level are mostly in age group of (16-18 years), and hence are not matured enough to choose accurately what profession to follow; neither they are aware about the necessities in a specific area nor about the major academic courses which will suite their

potentials or capabilities [3]. Hence, there exists an urgent demand for career counselling experts particularly in schools and universities to safeguard students' future. The counselling and guidance should be an integral part of schools and colleges, where the main intention should be to provide counselling to students so as to assist them to progress in their academic performances, select an appropriate career and make the most of their potentials. However, currently academicians or counsellors are being considered by limited students for attaining guidance. As in India, the career guidance and counselling concept is still in its preliminary stages and accessibility of trained manpower is insufficient [11].

Higher education forms the foundation on which the knowledge based society of 21st century can be build. According to survey conducted by Ministry of India Human Resource Development (MHRD) [12], the number of students registered for higher education have grown 12 times since last 4 decades as shown in Fig.1. Thus, indicating an imbalance ratio of career experts and students as limited career experts are available.

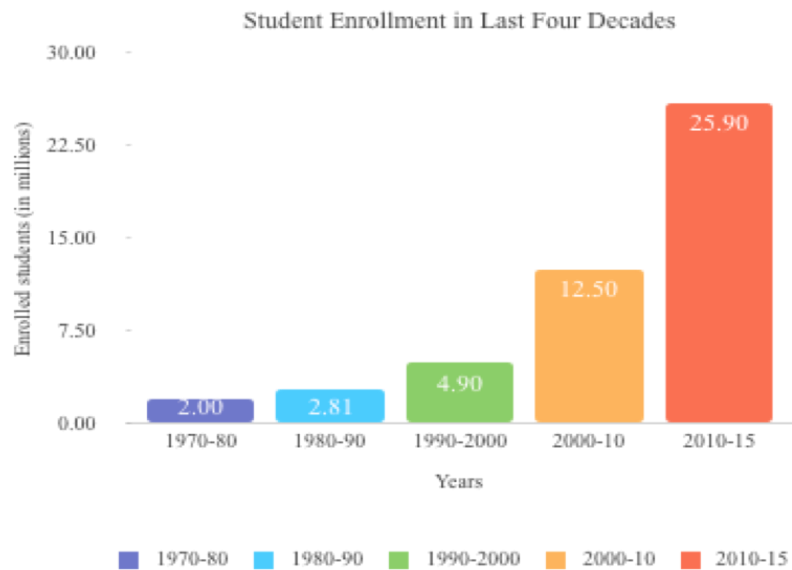


Figure 1. Student Enrolment in Last Four Decades [7]

Additionally, the enrolment rate in different fields is shown in Fig. 2 [13]. According to these statistics, humanities and engineering are the most preferred fields as compared to other streams which project substantial exposure and least competition. Thus, highpoints an urgent need to recommend students with career paths other than humanities and engineering so that they are able to relate to their abilities while shaping their career in a less competitive and non-traditional environment.

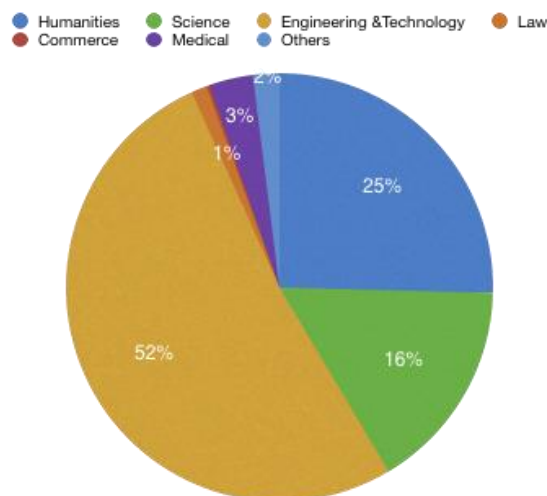


Figure 2. Stream Wise Enrolments [Adopted from [8]]

Consequently, with increase in number of educational institutions and the diverse courses being offered by them; the recommendations offered by human counselling experts may be inadequate and insufficient to decide whether a particular course will be suitable for a student [14]. Further, the conventional manual method followed in career guidance and counselling is inefficient and ineffective [15]. Some of the downsides in conventional career guidance approach are listed below:

- Reduced competency, reasoning speed and efficiency of career experts due to introduction of copious courses in education sector.
- Shortage or lack of full-time career guidance experts making it difficult to satisfy the desires of large population of students.
- Absence of career counsellors in all educational institutions.
- Confined access to career experts [11].

Thus, automation of career guidance and counselling process have considerable potential and will be of greater importance. This will not only save effort and time but will also streamline the task of professional advisors, students, staff and faculty. Further, automation with the aid of intelligent systems will deliver permanence, increased reliability, faster response, unemotional and steady results.

This paper comprises of V sections. Section II highlights the scope of developing solutions using numerous technologies. Section III discusses the related work performed in this domain followed by Section IV which highpoints the challenges as implied from the review conducted. Finally, Section V concludes the paper with future considerations.

II. DIVERSE SOLUTIONS

In order to solve career related issues currently confronted by youth, a wide variety of solutions are proposed by researchers in the past based on different techniques like: Data Mining, Machine learning, genetic algorithms, advanced statistical models, fuzzy logic, and Neural Networks.

In data mining, non-trivial and hidden relationships are discovered amongst large amount of diverse information. Data mining is a multi-disciplinary field and has emerged out as a recent research area in education sector. Numerous data mining algorithms and diverse approaches based on sequential patterns as well as on clustering techniques have been proposed to design different models for carrier counselling in educational research besides developing the complete educational process [16], [17], [18], [19]. However, computing systems developed using this technique results in highly complex and complicated systems which are difficult to maintain.

Machine learning is a sub-field of Artificial Intelligence-(AI), where computing systems are designed which are able to solve problems in the same manner as that of human beings. In recent years, continuous growth and progress has been witnessed in this field. Machine learning is being increasingly used in education sector with other technologies to develop numerous expert systems. Varying aspects in counselling problem can be dealt with machine learning techniques. The entire technique is based on how the system is able to learn from the domain knowledge. But, identification of appropriate parameters for learning is still a topic of concern in this field [20].

Over the past few decades, rapid interest is being witnessed in genetic algorithms. Genetic algorithms offer huge robustness and hence are increasingly used to provide solutions for many control, design and optimization problems. Besides, such techniques does not act as a black box as they present complete explanation of how a particular decision is made [14]. However, their performance is sturdily affected by the employed representation arrangements. Moreover, setting of parameters like crossover and mutation rate requires extensive experimentation. Consequently, resulting in development of highly complex, complicated and difficult to maintain systems.

Fuzzy logic based systems are capable of dealing with imprecise data when used in conjunction with rule-based techniques. Thus, better understandable and reasonable systems are being offered. However, this advantage turns out to be a weakness if rules are not elicited clearly [22].

Numerous advanced statistical techniques present in market are unable to completely translate the relation between domain parameters in multi-dimensional and non-linear data. Hence, such techniques are unable to provide solutions in educational sector which mostly deals with qualitative non-linear information [23].

Artificial Neural Networks (ANN) emerged out to be a more superior method than many statistical techniques, as they offer an easy forecasting of non-linear information. Such systems are efficient in recognizing features in incomplete or noisy data and hence are increasingly used in complex business applications such as predicting corporate bond ratings, stock market, credit-card fraud detection, business failure and bankruptcy prediction etc. [24], [25], [26], [27], [28], [29], [30]. An Artificial Neural Network (ANN) represents similar features to that of human neural system in terms of error tolerance, parallel function, flexibility and consistency. Such a system seeks to learn directly from relationships and patterns in data without requiring detailed information about interactions and structures in system. Further, these systems determine their reaction to new tasks by developing their own experiences through information acquired from predetermined samples [31]. Further, learning process in such models is controlled by training algorithms. The back-propagation algorithm has emerged out to be a popular training algorithm, which is grounded on iterative gradient-descent method resulting in error minimisation between predicted and expected network outputs. Further, this technique is being utilised for automation of knowledge acquisition process i.e. acquiring expertise of human career experts in academics.

Consequently, ANN form a better option for offering solution in career guidance and counselling as clear rules cannot be formulated here. At times, the career experts in complex real life scenarios take decisions based on instinct/heuristics founded on their experience of solving similar problems when no explicit/exact knowledge or information was present [32]. Automation of such type of problems requires computing systems with cognitive ability, which can be best achieved by using ANN. Several solutions have been offered in the field of career guidance and counselling using ANN, most of the solutions are present as Expert System (ES). However, they are developed primarily for specific curriculum of some institution and are predominantly utilised for selecting courses in such institutions [24].

A. Expert System (ES)

Expert System (ES) is an interactive computerised decision tool that manipulates both the heuristics and facts to offer solutions to difficult decision-making problems, depending on the information gained from an expert. Further according to [15], the computer programs that aim to emulate the behaviour of human expert form an Expert system. Wide adaptation of such expert systems is being witnessed in sectors of education, medicine, and accounting etc. In education sector, expert system turns out to be a successful and versatile tool for automation and computerisation of highlights the components in an Expert System.

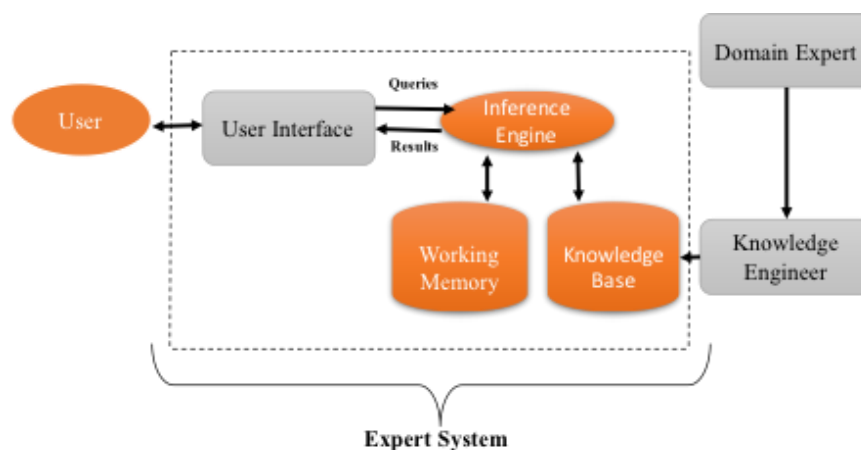


Figure 3. Standard Expert System

The fundamental components in ES architecture as shown in Fig. 3 are:

1. Knowledge Base: contains the domain knowledge essential for problem solving.
2. Database/Working memory: includes set of facts utilized for matching against the IF portion of the rules saved in knowledge base.
3. Inference Engine: forms the main processor, where the information is being processed. This module obtains relationships from the underlying knowledge base by evaluating, examining and interpreting the knowledge base rules to deliver suggestion, predictions and answers.
4. User Interface: is the communication link between the expert system and the user [15].

III. BACKGROUND WORK

In the recent years, several solutions have been proposed to enhance the contemporary process of selecting a career in the education system. A number of systems reviewed are discussed below.

In [14], the authors have implemented an online expert system offering career guidance to students studying in higher secondary levels in India. The system enables students to opt for better undergraduate courses among the several available courses at Pondicherry Engineering College. jSoup has been utilized by the system as a parsing technique for acquiring web page information about the courses/institutes at Pondicherry Engineering College. The prominent component of the proposed system i.e. the knowledge base has been constructed by the information acquired from web pages. IF-THEN criteria have been followed for knowledge base construction and the knowledge base has been categorized as student preferences and admission requirements as per University norms. Depending on the details being offered by students the appropriate recommendations are provided accordingly. However, the system fails to offer a generic solution targeting larger population, as it is a customized system for students aspiring to take admissions at Pondicherry Engineering College. Further, factors like Intelligent Quotient (IQ), personality traits etc., affecting a students' decision for appropriate career selection has not been considered.

In [33], the authors have attempted to provide a solution to problems faced by Nigerian universities while admission of students in numerous courses. The number of students seeking admissions in numerous courses offered by university is far more than the actual seats available for admission. A stand-alone, counsellor driven model has been developed using Artificial Neural Network aiming to provide a rich counselling and guidance to students in selection of appropriate careers as per their capabilities. The framework enables the human counsellor to provide appropriate recommendation to students regarding course selection in certain Nigerian Universities. Numerous factors have been identified and contemplated by the authors which influence student performance. These factors comprise tertiary examination, matriculation followed by higher secondary levels, location along with the types of tertiary institutions attended, age, gender, family background, ordinary-level subjects' score and subjects' combination. The factors eventually form the input parameters to ANN model. Multilayer perceptron architecture has been implemented and trained which works on students' data acquired through questionnaires from final year students of science department in Nigerian University of Ilorin and University Kano. However, the system fails to offer a generic solution in career guidance and counselling as it targets only science students while ignoring rest of the streams. Further, the personality traits of students have not been contemplated which largely contribute in appropriate career selection.

An online self-updating expert system has been implemented in [34], which offers guidance to students regarding selection of undergraduate courses in numerous colleges of Pondicherry. The proposed expert system has an Object Oriented Database along with a knowledge base framed using kappa PC method. The information that keeps the knowledge base updated has been acquired from web pages using jSoup parsing and pattern matching techniques. Domain-related queries are being taken as system inputs and most relevant details are provided by the expert system as output. The proposed model has not considered the factors that play a prominent role in career selection like personality traits, influence of family etc. Further, the model has been designed using students of specific geographical region. Hence, restrict its wider acceptability.

In [24], the authors have employed a machine learning approach where an artificial neural network model has been implemented in MATLAB, to provide assistance to human career counsellors in making better decisions. The scheme has considered the beneficiary's behavioural characteristics to generate a decision signifying the appropriate vocational stream/career choice that the individual can pursue. The Scientific Knowledge and Aptitude Test (SKAT) along with Differential Aptitude Test (DAT) battery have been utilized to evaluate an individual's capabilities in different fields. The authors have implemented a multi-layer feed-forward network while employing a variation of back propagation i.e. Levenberg Marquardt (LM) algorithm. The evaluation of the system was done using statistical measure techniques and results revealed that an agreement of 91% for all the test cases exists between Discriminant Function Analysis (DFA) and ANN. The two experienced career counsellors considered were also in 81% agreement with classification done by ANN. However, a disagreement of 27% was identified between counsellors over the entire test cases. Further, the other influential factors/parameters (cognitive style, interest, socio-economic status etc.) affecting the career selection decision has not been considered. Moreover, limited population has been targeted as small sample space has been manipulated by the system.

An intelligent web-based career guidance model functioning similar to human career counsellor in reasoning has been implemented in [15]. The scheme offers assistance to pre-tertiary students of science stream seeking admission in numerous study streams in higher institutions (Polytechnics or Universities) in Nigeria. The framework enables students to independently utilize the services of the system anytime and from anywhere via smart/mobile phones or desktops. A rule based expert system employing forward chaining has been designed, which manipulates various factors related to students such as IQ, favourite subject's combination in science followed by results of career interest inventory analysis to deliver career recommendations. Dataset comprises of 200 students of science stream, which participated in the career selection tests. The results revealed that 95% of the recommended careers by the system were relevant and accurate, 70% were satisfactory and 80% of the information offered by system on career guidance proved to be adequate. However, the system forms a customized model contemplating only science stream students while ignoring the non-science students followed by manipulating only limited parameters that affect the decision.

A Career Advice Model (CAM) based on active machine learning techniques and employing a rule-based decision support system has been proposed in [35], to support the decision making process of students for a suitable career. The system has been implemented using java programming language. Myers-Briggs Type Indicator (MBTI) model and fuzzy logic technique has been employed to identify personality type of an individual. Further, the academic ability tests are analysed and comparison with certain existing approaches has been performed. However, the wider acceptance of the system is limited due to consideration of a smaller dataset.

An online web-based career counselling system has been implemented by authors in [36]. The proposed expert system conducts a career quiz formulated on students' skills/hobbies/interests using WAMP (Windows-Apache-MySQL-PHP) technology. The framework enables the pre-tertiary students to better understand their capabilities and accordingly recommends appropriate career paths. The data for designing expert system has been acquired from surveys and human counsellors' interviews. The result analysis revealed an accuracy of 76%. However, the system has not considered prominent factors like students IQ, personality traits etc., which play major role in the career selection decision. Further, smaller dataset of 50 students has been considered which restricts its acceptance on larger scales.

The authors in [37], have designed a Decision Support System-(DSS) for automating counselling and guidance of higher secondary students in Nigeria for suitable career selection. The proposed system enhances the guidance being offered to students by enabling individual counsellors to reach at better decisions and accordingly provide assistance to students. Many factors were considered in the system to reach to a decision like ability, skills, interest, Intelligent Quotient, preferences, academic performances in the past, parent occupation and hobbies followed by influence of parents as well as friends. However, the system has been developed as a standalone application with the help of Visual Basics (VB), which confines the services being offered to limited personals. Moreover, only human counsellors could avail the services while the students cannot directly assess themselves so as to see what better career options they can opt in higher educational institutes. Also, students cannot decide independently on career choices as suggestions/advices from family plus friends are prominent parameters used to generate recommendations.

An Expert/Decision-Support-System (DSS) has been proposed in [38], enabling newly admitted students to select appropriate major in Gomal University, Pakistan. CLIPS language has been employed for implementing a rule based Decision-Support-System. As per the results achieved from module testing, the necessary recommendations regarding courses appropriate for fresher students are made. However, the system emerges as a standalone solution limiting the audience being targeted. Further, numerous factors that affect the career selection criteria has not been considered.

In [39], a customized, stand-alone expert system offering career guidance in a quick and cheap way to higher secondary students in Kenya has been developed. The model comprises of two modules: Institution entrance criteria component and personality analysis component. The formulation of rules and generation of knowledge base is done as per MBTI paradigm. However, the system being stand-alone customized only for students in Kenya limits its usage and thus fails to offer a generic solution targeting larger population. Further, the technique does not allow students to directly avail its services via smart phones, desktops or other electronic gadgets anywhere and anytime. The framework provides assistance only to career counsellors in making an appropriate recommendation.

As observed in [17], an automated career guidance and counselling system has been implemented for students in Pakistan. The system has considered a collation of J48 a decision tree algorithm and Case-Based Reasoning (CBR) techniques. Gender, students IQ, grades, hobbies and skills are being used as criterion in this system to offer an appropriate solution to

students. As per result analysis, CBR offers higher accuracy of 80% unlike J48 where 50-60% of accuracy is achieved. Hence, CBR emerges as a much better algorithm than J-48. However, the system is confined to specific geographical area, contemplating students of specific culture. Thus, fails to offer a generic solution targeting larger population. Further, smaller datasets have been considered.

Guidance to high school students has been provided in Malaysia with the help of an Expert system [40]. The solution being offered is web-based allowing access from anywhere and at any time. The system implements Case Based reasoning (CBR) technique, where the knowledge base is constructed using information gathered from guidance teachers and counselling experts. A database was developed from students' profiles, interests and personality traits. However, the system targets limited population confined to certain area in Malaysia (high school students) restricting wider acceptance of system results. Further, inadequate parameters are contemplated in designing the system, intelligent quotient which plays an important part in depicting the intellectual capabilities of students while recommending a career path have not been considered.

In [41], a Case-Based Reasoning (CBR) technique has been employed to develop an Expert system for automating career counselling and guidance process. A case study of 1000 Nigerian high school students has been considered aspiring to choose appropriate college courses. The proposed system delivers appropriate recommendations to students regarding career selection and the recommendations are based on the students' performances in certain selected subjects. A number of similarity matrices were contemplated and eventually Euclidean distance emerged as an efficient solution with classification error of 0%. The 800 cases of students are utilised for construction of Case-Base and 200 are used as test cases. The proposed model has been implemented in Mat lab. However, an individuals' personality which forms a prominent aspect in the decision of selecting a career has not been contemplated.

Certain sectors like in education, data analysis relies on qualitative data. Hence, a solution is required offering analysis of large amount of categorical data in less time and with minimum loss. A solution in the form of an ANN model allowing qualitative analysis from large amount of categorical data has been suggested in [31]. A Cascade-Forward-Backpropagation-Neural-Network (CFBPN) has been implemented to perform the analysis. The model offers more comprehensive information and data analysis about the characteristics of involved participants. The conceptual understanding test based on open ended questions has been employed for data collection. Besides considering smaller dataset of 210 individuals, it takes large training time.

Further, analysis of combined personalities or individuals' showing traits of more than one typology has been provided using rough sets together with lower and upper approximations in [42]. The presented study offers a significant means of determining sub categories using rough sets. The conceptual understanding test based on open ended questions has been employed for data collection. Rough set has emerged as an efficient solution as compared to statistical solutions when there exists large deviation of data from normal distribution. The results revealed out of 60 students, 29 showed characteristics of more than one typology. However, numerous other significant parameters are desired to be contemplated to provide with a much efficient analysis. Further, the analysis is applicable to only Likert-type attitude scales.

IV. CHALLENGES AND OPEN ISSUES

Due to the profound changes taking place currently in the field of technology as well as in work areas, career research must be done to address numerous key concerns. Several key issues have been identified; however, the prime implications from the review conducted have been underlined as:

- The accelerating automation and digitization of work has huge impact in shaping nature of career development, career choices and career counselling. Hence, the traditional approach of career guidance and counselling needs to consider additional features that have not been contemplated earlier [14], [15] [24], [33], [36], [37], [38], [40], [41]. One such feature is individual's personality traits, which play a prominent role in appropriate career selection.
- The systems [14], [15], [17], [33], [36], [38], [39], [40] fails to offer a generic solution targeting larger population, as they are customized systems confined to specific geographical area, where students of specific culture and educational background have been contemplated.

- Several offered solutions are developed using techniques like Data Mining, advanced statistical models, and genetic algorithms etc, [16], [17], [20], [35]. However, computing systems developed using these techniques results in highly complex and complicated systems which are difficult to maintain. Further, such systems are not adaptive in nature as it is likely that the economic changes and increased digitization will call for additional new behaviours, attitudes, and competencies among youths.
- Smaller dataset has been contemplated by a number of systems [14], [15], [17], [24], [31], [35], [36], [38], [39], [42]. Hence, restricting their acceptance on larger scales.
- Internet comprises large volume of heterogeneous information and finding relevant information from the enormous sources available is quite challenging task. Further, the dynamic nature of information and discovering location of reliable resources form prominent challenges for systems incorporating information from web to develop their expert systems. Hence, precincts the standard establishment of these systems [14], [15], [34], [36], [40].
- Several systems [14], [15], [34], [36], [40], offer a convenient and accessible solution by employing a web-based design. However, such systems are vulnerable to substantial confidentiality and privacy risks. Further, vacillating technology access specifically to high speed internet, will limit the availability of the offered services.
- Knowing what career attitudes, behaviours and possible career competencies are required for thriving in the new economy is a major concern. Limited study has been carried out in this field and certain models developed [31], [42], were found to take larger training time while considering insufficient parameters.

V. CONCLUSION

Issues pertaining to career form the major concerns among youths today. With increasing change in occupations, more number of individuals are confronted with acquainting themselves with upcoming industries and occupations that promise new career prospects in addition to employment opportunities. Hence, an imperative demand for automated career counselling experts in educational institutions to safeguard future of students exists. In this study, scrutinisation of numerous contemporary career counselling platforms centred on AI techniques have been presented. The significant contributions and shortcomings of the respective AI-based solutions have been enumerated explicitly. All the contemplated solutions were found to have loopholes and hence lacked in one context or the other. Further, there exists a lack of understanding of factors which guide the decision of career selection. This understanding is essential and fundamental for development of numerous policies in career guidance and counselling. Moreover, there does not exist a proper mechanism to identify the personality traits of an individual which form an important parameter in the construction of automated career guidance and selection schemes. Solutions based on deep learning can be developed in such expert systems to make them more intelligent and efficient. Hence, eliminating the drawbacks associated with conventional AI techniques. Also, appropriate data should be selected and analysed which can form a standard data set and eventually offer new insights in career trajectories, patterns and success predictors. Besides, additional open challenges and problems have been pointed out which need to be deliberated on while designing solutions, despite hoping to drive attention of research community.

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