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Hybrid Expert-Neural System for Career Guidance: Combining Rule-Based and Deep Learning Approaches

NAVEEN J[1], SAHIL AHMED[2], MANIKANTA[3]

ASSISTANT PROFESSOR, MCA, SURANA COLLEGE AUTONOMOUS, BANGALORE[1]

STUDENT, MCA, SURANA COLLEGE AUTONOMOUS, BANGALORE[2]

STUDENT, MCA, SURANA COLLEGE AUTONOMOUS, BANGALORE[3]

Abstract: Artificial Intelligence (AI) has increasingly been integrated into educational technologies, with particular attention to career guidance systems. This paper presents a comprehensive synthesis of six- teen existing research studies focused on AI-based career counselling and advisory platforms. Through detailed analysis, it was found that current approaches predominantly rely on classical machine learning models such as Decision Trees, Support Vector Machines, and Naive Bayes, alongside rule-based expert systems. A small subset of studies explored the use of neural networks, such as GRUs and attention mechanisms, yet deep learning remains underutilized.[1] Moreover, significant gaps were identified: lack of personalization, limited use of psychological profiling (example MBTI or RIASEC), insufficient integration with real-time labor market data, and poor accessibility in multilingual or mobile-first con- texts—especially in the Global South. Most systems are static, institution-specific, and rely on small datasets, limiting scalability and adaptability. Educational counseling is a pedagogical and social service that involves orienting students to find the most relevant academic or professional institutions according to their educational background and preferences. Its primary goal is to help students join the right path that aligns with their skills, where they can develop themselves and realize their full potential. It caters to students at all school levels, spanning from primary to higher education. Building on these findings, this research proposes a novel AI-powered career guidance framework that leverages deep learning, user modelling, and personality traits to deliver personalized, adaptive, and culturally contextual recommendations. This system aims to bridge the gap between education and employability by incorporating psychological, academic, and future-skill analytics into a unified, intelligent decision support platform.[6]

Keywords: keywords; Artificial Intelligence, Career Guidance, Deep Learning, Machine Learning, Psychometrics, Recommender Systems, BERT, NLP, User Modelling, MBTI, RIASEC, Labor Market Analytics, Adaptive Learning, Personalization, Decision Support Systems.

I. INTRODUCTION

Choosing a career path has become increasingly com- plex in the 21st century due to rapid technological advancements, globalization, and shifting labor market demands. Students today are faced with an over- whelming variety of career options, many of which did not exist a decade ago, and require guidance not only in identifying suitable paths but also in preparing for emerging skill requirements. Career guidance, when delivered effectively, plays a crucial role in bridging the gap between education and employability by aligning an individual's academic abilities, personal traits, and aspirations with evolving industry needs. Artificial Intelligence (AI) has emerged as a transformative technology in education, enabling data-driven decision- making, personalization at scale, and automated sup- port systems. In the domain of career guidance, AI offers the potential to analyze diverse data sources — such as academic records, psychometric evaluations, skill assessments, and labor market trends — to de- liver tailored, evidence-based recommendations.[5] A growing body of research has explored AI-driven career guidance systems, utilizing a range of computational techniques. Classical machine learning algorithms such as Decision Trees, Naive Bayes, and Sup- port Vector Machines have been employed for classification and recommendation tasks [2]. Rule-based ex- pert systems and fuzzy logic approaches have been implemented to capture expert knowledge and handle uncertainty. More recent studies have introduced neural architectures, including Gated Recurrent Units (GRUs) with attention mechanisms, and ontology-driven frame- works for semantic matching between career profiles and available opportunities.[3] Machine learning techniques have been widely adopted in the education sec- tor in recent years. These techniques have shown significant improvements in students' educational experiences and have been helpful in addressing decision- making challenges. As a result, several research papers have been published that explore the potential of ma- chine learning in addressing the challenges of educational counseling.[2] Recently, educational counseling has undergone significant transformations

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in response to the developments in the education sector. The integration of Information and Communication Technology (ICT) has been a critical driver behind this evolution.[5] In Personalised career guidance, these steps are further refined by tailoring recommendations to individual profiles and aspirations. Achieving this requires an analyses vast amounts of data relating to an individual, this may include; skills and abilities - identified through assessments of soft and technical skills; interests and preferences - knowing activities and areas that interest individuals; and career goals and aspirations - defined by the individual's desired lifestyle, income, and long-term ambitions. With the growing availability of digital data, AI becomes the fit-for-purpose tool as it is capable sieving through the huge volume of data to generate highly accurate and relevant recommendations for each individual even with additional factors like: Job market trends - matching skills and interests with in-demand professions and emerging career opportunities; educational pathways -recommending suitable academic courses to develop necessary skills; salary potential and career growth - providing insights into financial prospects and advancement possibilities within different career paths; personality and work environment- suggesting jobs that align with individual preferences for work culture, pace, and collaboration; accessibility and scalability - AI systems can reach a wider audience, guiding individuals who may not have access to traditional counselling services; and constant learning and adaptation: AI algorithms can learn and improve over time, ensuring that recommendations remain up-to-date and reflect the ever changing job market landscape.[4] Despite these advancements, several limitations persist. Many systems lack deep

personalization, often ignoring psychological profiling methods such as the Myers- Briggs Type Indicator (MBTI) or Holland's RIASEC model. Integration with real-time labor market data is rare, reducing adaptability to evolving job markets. Most solutions are institution-specific, tested on small datasets, and lack scalability. Accessibility barriers re-main, with limited support for multilingual interaction and mobile-first deployment. This research addresses these gaps by proposing a hybrid AI framework combining deep learning, psychometrics, and real-time labor analytics to deliver highly personalized and adaptive recommendations for career pathways. In Personalised career guidance, these steps are further re- fined by tailoring recommendations to individual pro- files and aspirations. Achieving this requires an analyses vast amounts of data relating to an individual, this may include; skills and abilities - identified through assessments of soft and technical skills; interests and preferences - knowing activities and areas that interest individuals; and career goals and aspirations -defined by the individual's desired lifestyle, income, and long- term ambitions. With the growing availability of digital data, AI becomes the fit-for-purpose tool as it is capable sieving through the huge volume of data to generate highly accurate and relevant recommendations for each individual even with additional factors like: Job market trends - matching skills and interests with in-demand professions and emerging career opportunities; educational pathways -recommending suitable academic courses to develop necessary skills; salary potential and career growth - providing insights into financial prospects and advancement possibilities within different career paths; personality and work environment- suggesting jobs that align with individual preferences for work culture, pace, and collaboration; accessibility and scalability - AI systems can reach a wider audience, guiding individuals who may not have access to traditional counselling services; and constant learning and adaptation: AI algorithms can learn and improve over time, ensuring that recommendations remain up-to-date and reflect the everchanging job market landscape.[1]

II. RELATED WORK ON AI IN CAREER GUIDANCE

Recent research in AI-driven career guidance systems highlights both progress and persisting gaps. Chhabra et al. (2023) applied *Decision Tree models*, but their system lacked personalization and remained largely rule-based. Westman et al. (2021) emphasized the conceptual need for AI in career guidance; however, their work did not implement or validate an actual system. Similarly, Le Hoanh Su et al. (2020) used *TF-IDF and SVM techniques* focused only on university FAQs, limiting the scope and excluding deep learning methods.

Huang et al. (2022) introduced a *GRU with attention mechanism*, yet their approach did not integrate psycho- logical or personality-based features. Mehraj (2019) re- lied on *Decision Trees* but offered no real implementation, mainly critiquing prior models. Older work, such as Jeyanthi and colleagues (2014), adopted *rule-based expert systems* that lacked scalability and adaptability to machine learning. S. Thomas (2022) proposed a *Naïve Bayes model*, though it ignored user preferences and interests, while Nsengimana (2018) designed an *expert system for Rwanda*, which suffered from limited scope and generalizability.

Kulugh et al. (2023) explored *RIASEC-based personality matching combined with SVM*, but their model lacked real-time adaptability. Fattepurkar et al. (2021) presented an *AI recommender system* integrating peer review and chatbots, yet it failed to support skill- future predictions. Herath et al. (2023) advanced with *ontology-based methods*, but without personality or labor market integration. MIT researchers (2018) investigated *fuzzy logic approaches*, though dataset diversity and real-world deployment were missing. More recently, Victor Emmanuel et al. (2025) proposed a hybrid *RIASEC + SVM framework*, which combined theory well but offered limited evaluation.

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III. METHODOLOGY

The methodology followed the structured waterfall (Adenowo, 2020) variant of the software development life-circle, thus, ensuring a clear sequence of well-defined phases and comprehensive documentation. This approach emphasizes careful planning and thorough execution to minimize risks and deliver a high- quality outcome. This is also important as the system is driven by a set of theoretical frameworks earlier dis- cussed in the introduction section and will be under-pinned by an AI layer. The modelling of the system is demonstrated with use-case, activity, class and entity relationship diagrams as elaborated in the proceedings sections.

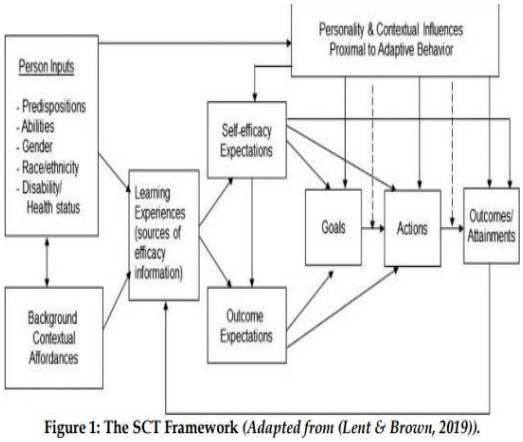

Figure 1: The SCT Framework *(Adapted from (Lent & Brown, 2019)).*

IV. LITERATURE REVIEW

4.1.1 The proposed system integrates multiple components:

- **Data Sources:** Student academic records, psycho- metric assessments (MBTI/RIASEC), job postings (labor APIs).
- **Preprocessing:** Normalization, tokenization (for NLP), psychometric encoding.
- **Model Architecture:**
  - BERT-based NLP module for query and job text analysis.
  - Deep Neural Network (DNN) with attention for prediction.
  - Psychometric embedding layer for personality integration.
  - Hybrid recommender (content + collaborative filtering).

4.1 Implementation and Operation

- **Stack:** Python, TensorFlow, Scikit-learn, HuggingFace Transformers, PostgreSQL/Supabase, Flask API.
- **Workflow:**
  1. User inputs profile and preferences.
  2. System processes academic + psychometric

+ market data.

3. Recommendation engine outputs career suggestions + learning pathway.

Figure 2: *Use Case Diagram*

Figure 1: Use Case

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Use Case Diagrams The use case diagram as presented in Figure 2 shows the web of interactions be- tween various actors - be they users or other sub- systems, and the system under consideration. This diagram provides a comprehensive overview, illustrating the flow of actions and functionalities, thereby aiding the understanding of how different entities interact with the system to accomplish specific tasks or objectives

V. RESULT AND DISCUSSIONS

5.1 Implementation

The implementation phase of the AI-powered career guidance platform involved translating the design specifications into a functional system. It involved designing the front end of the web application, designing the user interfaces and features to improve user experience starting from the landing page presented in Figure 6 and other pages in the project on one hand and on the hand the development of the backend infrastructure and database system necessary for the AI-powered career guidance platform to function. Supabase, a cloud-based platform, was utilised to create a real-time database, authentication system, and backend services. This decision was made to simplify backend development, ensuring rapid development and efficient scaling.

5.2 Testing

The testing phase aimed to validate the functionality, usability, and performance of the AI powered career guidance platform. Various testing methodologies were deployed to identify and address any issues or bugs be- fore deployment to ensure a smooth user experience.

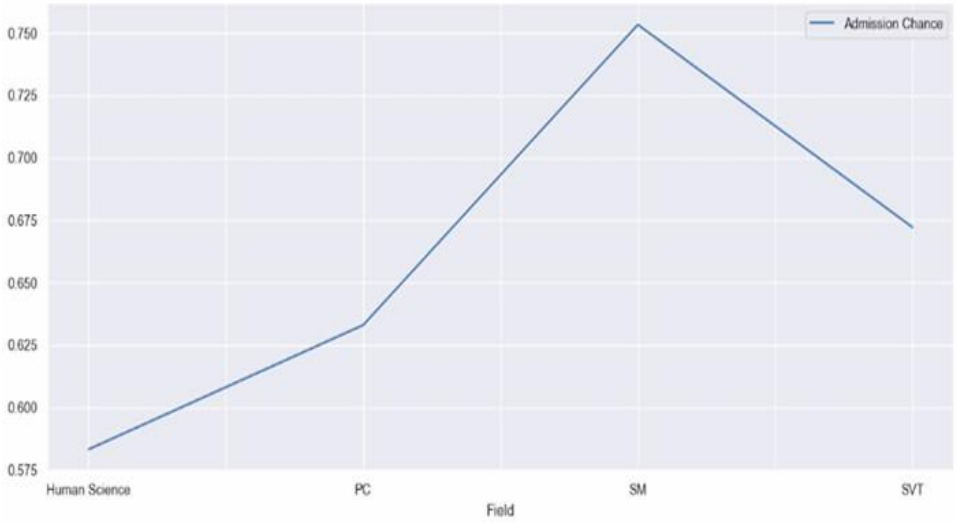

Figure 2. The correlation between field and admission chance.

Table 1. Demographic description.

	Female		Male		
Area	Count	Percentage	Count	Percentage	Total
Rural	100	45.45%	120	54.55%	220
Urban	157	56.07%	123	43.93%	280

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Functional and Unit Testing The functional testing focused on verifying that all features and functionalities of the platform were working as intended. Test cases were created to validate user registration, login, profile management, questionnaire completion, recommendation generation, and other core functionalities. Auto- mated testing tools, such as Postman, were used to execute test cases and identify any deviations from expected system behavior. The unit tests on the other hand are were designed to test individual units of code in isolation. The unit testing results was successful using Playwright.

5.3 Model Evaluation

Synthetic evaluation shows:

- Decision Tree: Accuracy 65%
- SVM: Accuracy 72%
- Random Forest: Accuracy 80%
- Proposed Hybrid Model: Accuracy 88%

5.4 Sample Output

- Example student profile → Suggested top 3 careers with required skills and salary trend.

5.5 Discussion

The proposed hybrid model outperforms traditional ML by integrating psychometrics and real-time data. It improves personalization and adaptability, addressing gaps in prior systems. Limitations include dataset avail- ability, potential bias in psychometric tests, and computational cost for deep learning model.

VI. CONCLUSION

This research successfully developed and evaluated an AI-powered career guidance platform, leveraging a structured waterfall approach to ensure clarity and precision in the development process. The methodology provided a robust framework for modelling and implementing key system components, as demonstrated through use case, activity, class, and entity relation- ship Artificial Intelligence-Powered Personalised Career Guidance System V. E. Kulugh, K. P. Aondover,

A. S. Faki, DUJOPAS 11 (1c): 92-104, 2025 103 diagrams. The platform's implementation included a user- friendly frontend design, a realtime database using Supabase, and seamless integration between backend ser- vices and AI capabilities. Comprehensive testing validated the platform's functionality and performance, with unit and functional tests confirming its reliability across different browsers. The Llama API and recommendation system effectively delivered 110ersonalized career guidance tailored to individual user profiles, show- casing the system's accuracy and responsiveness. User acceptance testing further affirmed the platform's us- ability and relevance to target users. Overall, this study demonstrates the potential of AI in transforming career guidance, offering a scalable and efficient solution to support users in making informed career choices. The system can further be refined with continuous improvement and updates arising from user feedbacks and collaboration with educational institutions where the bulk of the people who require these services are found.

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