IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received 29 January 2024, accepted 14 March 2024, date of publication 22 March 2024, date of current version 10 April 2024.

*Digital Object Identifier 10.1109/ACCESS.2024.3381032*

RESEARCH ARTICLE

# Personalized Career-Path Recommendation Model for Information Technology Students in Indonesia

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**ABSTRACT** One of the challenging decisions for students is taking a job specialization. To make their decisions, they use subjective perceptions of friends or family due to the lack of guidance and limited resources. This increases the risk of dissatisfaction with the work environments. To address these drawbacks, this study presents a personalized career-path recommendation model (CPRM) to provide guidance and help college students choose information technology jobs. The design of the CPRM is based on the personalized Naïve Bayes (p-NB) algorithm with three primary sources: job profiles, personality types, and subjects. The association between personality type and college students was established using samples of 104 computer science students enrolled in private universities in Indonesia. CPRM was implemented as a web-based application. This study evaluated the model by measuring the quality of the recommended items to determine whether the proposed model is well accepted by users. The model considers educational data mining grounded theory (EDM-GT) data integration and hierarchically related concepts. CPRM has been validated by Information Technology (IT) professionals and three psychologists in Indonesia through focus group discussions. The evaluation results showed that more than 83% of respondents were satisfied with the recommendation model. Hence, CPRM can provide automatic academic advisors and guidance to computer science students interested in pursuing careers in IT jobs. The result shows that CPRM is the first career path recommendation model based on EDM-GT to target the computer science community in Indonesia.

**INDEX TERMS** Educational data mining, grounded theory, information technology, naïve bayes, career path recommendation model.

## I. INTRODUCTION

The time-consuming process is one of the challenging things for students regarding finding information on job specialization that matches their interests. Selecting the right subjects to create a suitable career path is a complicated task [1], [2]. Career path refers to any jobs in Information Technology (IT) proposed for undergraduate students. The students must explore abundant information to optimize resources that can enable them to match their suitable and interesting jobs. Searching available subjects, accessing each source, and understanding every subjects syllabus can be time-consuming for searching information needed [3], [4]. Different career paths can be chosen although some subjects titles are similar [5].

Studies have shown that oversight in career selection is caused by employees not knowing their interest in a job, which leads to inappropriate performance. Compatibility of interests and personality type are important factors for obtaining good performance and satisfaction for someone who pursues a job [6], [7], [8]. Interest is a person's tendency towards science skills in a job that he must master. Interest

The associate editor coordinating the review of this manuscript and approving it for publication was Ka Wai Gary Wong.

is part of the personality type that can be used to help choose a suitable career. The personality type can be used to predict a person's interests, which is a factor in their professional success [9], [10]. The job profile chosen by a student is linked to the learning path with career goals, and environmental influences such as seniors, mentors, parents, friends [11], and interests as measured by their personality type [9], [10], [12].

Research on career selection and recommendations cannot be separated from artificial intelligence (AI) approaches such as text mining [13], [14], [15] and data mining [1], [3]. Research in this field has also discussed matching job profiles with job seeker profiles [16], [17] and selecting appropriate courses [1], [18]. The job level associated with worker experience also covers the job recommendation system as proven by [19]. Students' interest in choosing a study program that suits the career goals and subjects recommended by professionals to be achieved [18], [20]. The types of work and skills required are interesting knowledge to be declare [3], [21], [22], [23].

Based on the extensive previous research, we identified some limitations, such as the fact that they only discuss the relationship between the technical skills required of employees without discussing whether the workers are involved in matching their personal interests. The previous model does not involve expert judgment in IT; therefore, it cannot be validated practically. Professional psychology has also not been implemented as a justification for workers' interests in their respective work fields. Measurements of recommended items such as learning materials, type of work, and novelty of the model, have not been carried out scientifically.

To overcome the limitations of previous research, this study proposes a novel model called educational data mining-grounded theory (EDM-GT), which combines technical skills, especially in the IT field, and validates the model through the involvement of experts in the fields of IT and psychology to measure a person's interest in a job. A mixed-method approach was used to create the proposed model. Mixed methods that combine qualitative and quantitative data are well-established approaches for collecting, extracting, and analyzing studies. Mixing qualitative and quantitative data could help understand the research problems properly and propose a better solution. The mixed method enables an increase in student performance in the field of education [24], [25].

This study aimed to help computer science students choose their career paths and obtain recommendations for supporting subjects according to their personality type by extracting and analyzing them through the EDM-GT model. The objectives of this study are to contribute to two findings: first, as an automatic academic advisor to guide students to initiate career paths, and second, to evaluate the subject structure of higher education as an industry need.

Educational data mining (EDM) uses to discover meaningful and useful knowledge from huge data in the education field. They are also concerned with developing methods or models to explore unique types of data originating from educational environments including answers to important educational questions. Several studies have shown that EDM can be used to provide recommendations for choosing something, such as, course selection, performance in achieving academic grades, and career selection [26], [27]. Grounded Theory (GT) is an inductive theory development method that contributes to the formation of substantive theory through an abstract heuristic process. GT is based on efforts to collect field data, which are then developed and proven through systematic data analysis. The results can test existing theories and/or find a new theory [28]. In its development, GT has not only been used in social research, but has also spread to computer science research, such as artificial intelligence, software engineering, and information systems. The data and techniques used are also varied, such as qualitative and quantitative data, text processing techniques such as data mining, natural language processing (NLP), and sentiment analysis are also possible to use [29].

## II. RELATED WORK

This section explains an explorative review of recommender systems in the education field, especially career-path recommenders. Several classifications of recommender systems designed to contribute to student learning. However, this review focuses on personalized job recommender systems for different methods and educational fields. The reader might have a comprehensive review, of another type of recommendations from the literature below [3], [30], [31].

The implementation of personalized career-path recommender systems depends on various features, such as the user's personal information, job profile, course profile, subjects, and personality type. Table 1 summarizes the various recommender systems including implementation features and datasets.

Previous studies were designed to guide practical learning systems for job recommendation models such as subjects, personal types, and skills. For example, an ontology job recommender system was proposed in [32] to model areas of knowledge representing the professional skills of every job. A semantic structure model recommender system to define required skill every job information using character trigram format can increase the efficiency of the system has been proposed by [22]. Information technology (IT) skill classification has been found to be a suitable career recommendation for IT students. K-means clustering mixed with K-NN classification is used to determine the proximity between student skills and the IT job field [21]. The integration of heterogeneous data and community detection using a graph mining approach was researched by [33]. It explores and analyzes a wide course description from job advertisement data.

Upskilling for professionals can be achieved by integrating skill communities that enable cross-domain information recommendations, such as educational profiles and job recommendations. Research by [20] proves that personality

**TABLE 1.** A review of personalized job recommendation model.

| Reference | Feature | Dataset | Research Method | Field |
|---|---|---|---|---|
| Meta-heuristic algorithms for learning path and job recommender [2] | Learning outcome, job profile, course | Coursera | Quantitative | Information Technology |
| GSTEM-CAT [20] | Personality type and knowledge test | Senior high school students | Quantitative | Engineering |
| Collaborative filtering method for information technology recommendation system [21] | Job type, skills, subjects | IT Professionals of LinkedIn | Quantitative | Information Technology |
| Semantic structure model for job recommendation [22] | Job profile (required skills), job seeker personal information (skills, location) | Job seekers of Nukari.com and CareerBuilder.com | Quantitative | Accounting |
| Ontology for job recommendation model [32] | User personal information (demographic information, job area, skills), course profile (demographic information, course assessment), job profile (required skills) | Users of LinkedIn | Quantitative | Information Technology |
| Personalized career education recommendations [33] | Job profile, skills, course profile | Users of Careerbuilder.com and students at Indiana University Bloomington, Amerika | Quantitative | Information Technology |
| Artificial intelligent-based recommender system for personalized job [34] | Job profile, learning topic, learner profile | Higher education | Qualitative | Information Technology |
| Job recommender system based on social network organizations [35] | Job profile, user profile, | beeBee social network | Quantitative | General |

types, career development, and success have important connections. Personalized recommender systems have been proposed to help students in their career search.

As mentioned in the literature, those are designed to provide career recommendations for students while considering various features using a quantitative method. However, none is modeled to consider higher education students in the IT fields for choosing a specialized job using mixed methods that could better understand research problems and propose a proper solution.

Some recommender systems have been role as academic advisors by recommending items such as learning materials, fields of study, courses, etc. A heterogeneous graph approach used to identify skill communities enables students of Indiana University Bloomington to define cross-domain information recommendations [33]. Their system integrates career and educational data by implementing heterogeneous graph indexation to assist students in course decision-making.

Previous research stated that students' careers are an important factor that can influence them to choose a specific subjects [4]. Reference [3] using a social navigation approach to analyze students' assessment and providing course recommendations based on their career goals. According to Table 1, the research gap of this study combines 3 fields, namely academic, industrial, and psychology using mixed methods to understand research problems well and provide appropriate

solutions. Since existing research only analyzes several features separately, for example from job profiles, user profiles, and academic profiles, or only uses limited datasets, for example only from academic data or job service advertisements separately. This study gives new perspectives such as the academic field uses learning material features obtained from course structure documents using the Grounded Theory (GT) approach, and the industrial field uses features of the type of work and skills needed using web scraping, text mining, and data mining techniques. The psychological field uses personality types integrated by the GT approach and distributing questionnaires to test the resulting model. The new dataset produced consists of the types of jobs and IT skills required by industry, the suitability of types of jobs with supporting elective subjects, and a map of personality types in Indonesia. This dataset will be useful for students in the field of computer science to prepare for future career choices.

The clarity of student decision-making and reasoning processes can be improved by implementing educational recommendation techniques. Recommender systems are challenging to better understand students' interests by leveraging personality type as the purpose of the domain [36]. Therefore, this study implemented a career-path recommender framework using mixed methods for IT students based on job profiles, subject profiles, and personality types.

The main contributions of this research as follow:

1) Construct a new framework by integrating educational and psychological fields using educational data mining and grounded theory (EDM-GT) techniques to personalize students' information.
2) The framework uses a personalized recommender system to map the profiles of the job and subjects according to the personality type of the student.
3) Extracting and integrating data from various sources and mapping them is used to obtain a comprehensive knowledge of the recommended job and subject.
4) To validate the proposed model, we involved expert judgment, as well as IT professionals, and psychologists.

## III. PROPOSED PERSONALIZED CAREER-PATH FOR INFORMATION TECHNOLOGY JOB FRAMEWORK

This study proposed a personalized recommender system based on EDM-GT. Data acquisition layer designs to extract and integrate information from various sources based on text mining and grounded theory. The information retrieval was classified into three primary types: career information, subject information, and student information. Integrating information using EDM-GT yields an optimal result. Processing layer aims to build a personalized CPRM based on EDM-GT mapping between the student profiles and the subject profiles that will help personalize students' information. To provide appropriate recommendations to users, we propose a personalized career path recommendation model. User profiling based on item profiles and Naive Bayes is used to achieve good performance [23] and can predict personality through user profiles with a high awareness factor accuracy [37]. Another study that used personality tests for workforce recruitment using the Naïve Bayes algorithm and MBTI approach provided an accuracy of over 78% [38], [39]. The user application layer aims to propose recommendations for jobs and subjects. The user feedback was used to evaluate the system as described in the evaluation section. This study aims to increase the accuracy and performance of a novelty model using personalized CPRM with an enhanced EDM-GT technique.

### A. FRAMEWORK OVERVIEW

The proposed personalized Career Path Recommendation Model (CPRM) is a framework that focuses on recommending jobs and subjects to students by utilizing a comprehensive model that combines educational data mining and grounded theory (EDM-GT) techniques to personalize students' information. Fig. 2 explains a CPRM consists of four main layers. The first layer is the data-acquisition layer as the data-collecting stage. It gathers and extracts useful information from various sources. The database layer used to store all the jobs, subjects, and student information. The main functional layer includes the EDM-GT and recommender engine models. A detailed explanation is described in the next section. The user application layer performs the user interface model. It is responsible for user interaction with the framework. This layer also provides feedback on the recommendation list as the evaluation of this study. Our framework consists of six stages as follows:

1) Extract all the information retrieval from various sources to construct the model.

2) Construct the IT jobs' profiles by extracting all the important information regarding job features and storing it in the database.

3) Construct the subject profile through subject structure documents.

4) Build a student profile using a personality type test. Four attributes have been identified to profile the student into the model and user preference for the recommended subjects.

5) Build dynamic personalized CPRM mapping to link the student profile with job and subject profile.

6) Use an EDM-GT technique to obtain recommender system using a personalized Naive Bayes (p-NB) algorithm.

Suggestion of recommended jobs and subjects for students are provided in the last step. A detailed purpose of each of the components is explained in the next section.

### B. DATA ACQUISITION

The essential approach to providing the CPRM framework is a text-mining grounded theory technique. Therefore, various information needs to be acquired to support this framework.

1) Job profiles are available through the job advertisement portal for career information. The web scraper technique was used to reveal IT job profiles using the average linkage

hierarchical clustering (ALHC) algorithm. It analyzes the web page based on the job description and extracts the feature information. Extracted feature information belongs to one of the features that we have used in this study. Two features of the job were identified in this study: job title and required skills.

2). Data from the subject structure is extracted and analyzed using the grounded theory approach. Learning materials are revealed through that extraction.

3). The personality type of each student was identified using the MBTI test, a psychological questionnaire. This test describes the personalized value of each student. However, the feature that has been constructed in the framework is based on subject and job recommendations.

### C. MAIN FUNCTIONAL

This section describes the most important part of the proposed framework which consists of two models. First, the EDM-GT model, which includes the construction of IT job profiles for the student and the subjects and personality types that map these techniques to provide important knowledge of the recommendations. IT job profiles are used as the input in the recommender engine which is the second model in this layer.

We implemented the p-NB algorithm to recommend jobs and subjects to students and used the model to enhance the performance of the recommender engine. The EDM-GT model was used in the proposed approach to model knowledge regarding the job profile content (job title and required skills), subject profile content (subject title and learning materials), and personality type of the student. The EDM-GT refers to a combination of qualitative and quantitative methodologies that aim to develop a theory through an abstract heuristic process by integrating data mining concepts in the education sector [26], [27], [29]. The EDM-GT provides applications to reveal the context of the job profiles, student profiles, and the subject content features based on their semantics. The hierarchical structure of the EDM-GT allows the researchers to develop the domain contents by describing the learning fields and building a practical model [40], [41].

Three modules were constructed in this study. First, the job profile; second, the subject profile; and third, the personality type profiles. The Google Collaboratory tool was used to evaluate the model by mapping hierarchically between the modules and computing the connection between them. Knowledge, represented by the EDM-GT model, significantly helps personalize students' information.

#### 1) JOB PROFILE

The process of this module as presented in fig.1 data acquisition was carried out through a web scraping process on the websites of techinasia and jobstreet indonesia. From the results of the web scraping, the job title and required skills for text preprocessing were selected. Text preprocessing is carried out for dataset cleaning procedures from various types

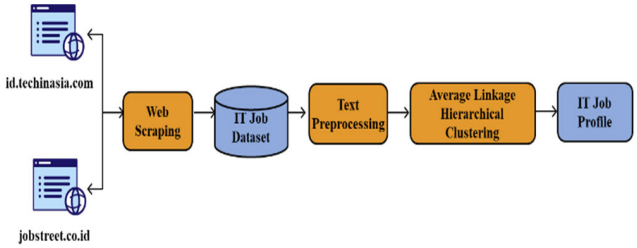


**FIGURE 1.** Information technology job profile phase of career path recommendation model.

of errors or corrupted data, the stages carried out are case folding, punctuation removal, stopword removal, tokenization, and lemmatizer.

This stage consists of four steps. The first step is tokenization to separate text into tokens for subsequent analysis such as words, numbers, symbols, and punctuation marks. The second step is stop word removal aims to reveal custom dictionaries. Terms "and," "or", "the" are deleted from the document using a stop list algorithm. The third step is standardization and cleaning by removing numbers, punctuation marks, or special characters such as periods, commas (,), and question marks (?) aims to standardize cases. The last step is lemmatization, which transforms any tense into the present tense. The output of these steps is tokens to be processed in the ALHC algorithm. The result of text preprocessing then proceeds to gain IT job profiles through a data mining approach called average linkage hierarchical clustering (ALHC). It resembles tree structures formed through a multi ranking group process. Reference [42] proved that ALHC outperforms any other clustering technique such as single and complete methods in text mining research. Reference [43] stated that ALHC can improve accuracy by combining it with other methods. Hierarchical clustering of IT jobs is performed to determine the skills needed for each type of work [44].

Table 3 shows a systematic semantic analysis of the IT job profile which has been revealed through the ALHC algorithm as stated in our previous research [45]. This study identifies that job profile as duties and responsibilities in technical competencies for every job. Those competencies are limited to programming language, databases, tools, and frameworks.

#### 2) SUBJECT PROFILE

The subject profile referred to in this study is an elective subjects contained in the curriculum of the computer science study program. The subject profile module presented in Fig. 3. Each elective subject had learning materials that must be given to the students. Learning materials will be mapped to each type of suitable IT job using Grounded Theory (GT). This research uses practice-based documents, such as projections of workforce needs in companies based on competence in the information technology and communication sector in Indonesia in 2022–2025 [46], Computing Curricula 2020 [47] and curriculum structure at the PLN Institute of Technology and School of Computer Science Bina Nusantara University.

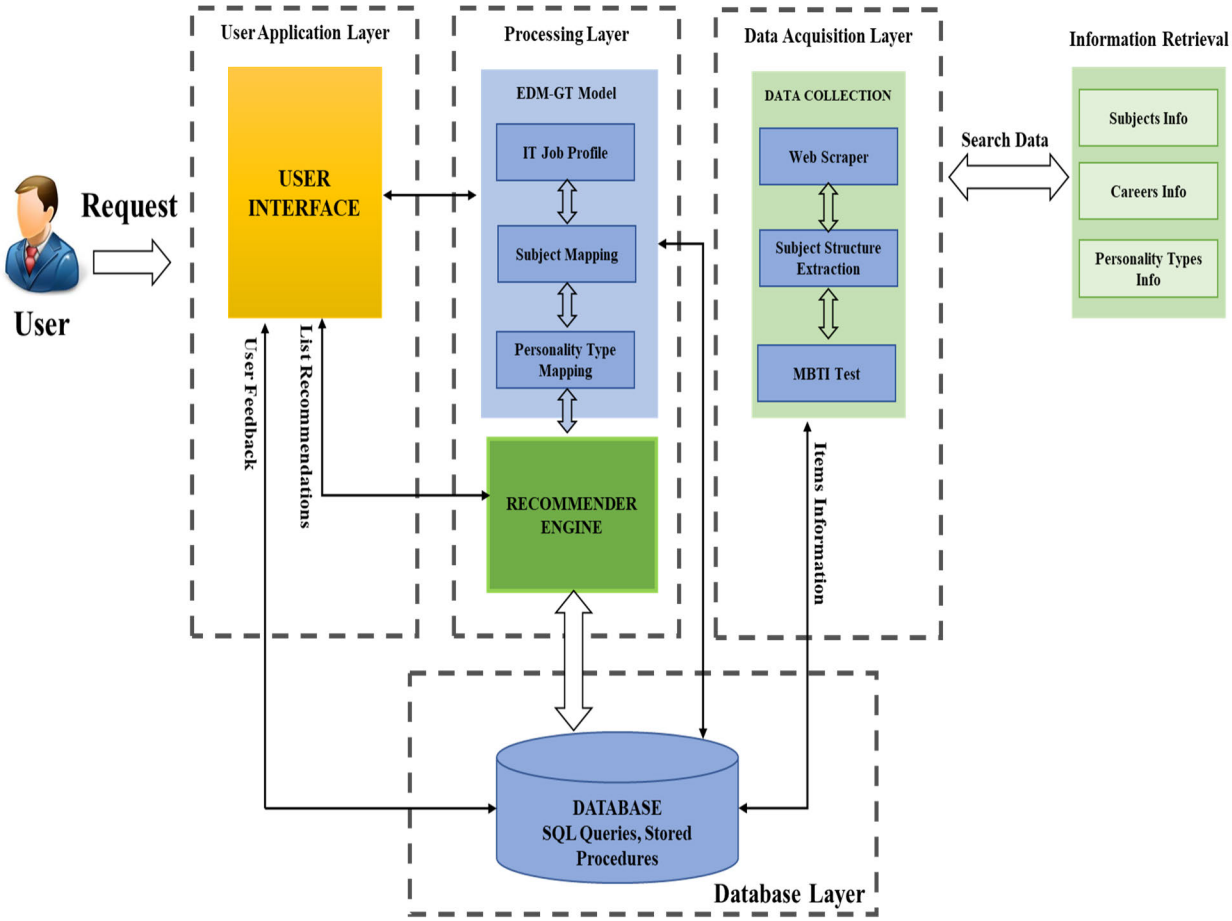


**FIGURE 2.** Personalized career path recommendation main architecture based on the EDM-GT model.

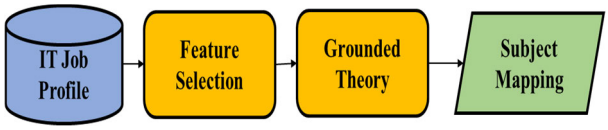


**FIGURE 3.** Subject profile's mapping phase of CPRM based on EDM-GT model.

Relevant practice-based or industry-based research topics tend to lead to successful GTs because they increase the likelihood of finding sufficient evidence from practice and conducting field observations [29].

The grounded theory approach analyzes and extracts primary and secondary data or documents through three stages: open coding, axial coding, and selective coding. Subject mapping was performed using the GT process as shown in Table 2.

Each job was mapped to an elective subject using the EDM-GT model. The suitability of courses for IT work was validated by twenty-two lecturers from each subject and ten IT professionals. The validation process through focus group discussions (FGD) and questionnaires involving lecturers and IT professionals. The summarization of the FGD was processed using the GT approach via Nvivo 12 software. This validation is expected to have a good impact such as public trust in the proposed model. Of the ten jobs, it is known that there are two jobs: computer support specialist and network

**TABLE 2.** Subject mapping of EDM-GT model.

| Job Title | Subject |
|---|---|
| Web Developers | Web Programming, Advance Web Programming |
| Computer System Analysts | Geographical Information System |
| Software Developer Quality Assurance | Software Engineering Management, Software Quality and Metric |
| Information Security Analyst | Computer Vision |
| Computer Programmers | Mobile Programming, Competitive Programming, Advance Mobile Programming |
| Computer Support Specialists | |
| Database Administrator and Architects | Geographical Information System, Advance Database |
| Computer and Information Research Scientist | Embedded Systems, Computer Vision Data Mining and Warehousing, Data Science, Embedded System, Soft Computing, Computer Vision, Programmable Logic Controller, Big Data |
| Computer Network Architect | Embedded Systems, Introduction to SCADA technology |
| Network and Computer System Administrator | |

**TABLE 3.** Information technology job profile for career path recommendation model [45].

| Job Title | Programming Language | Specialized Type or Other Name | Duty | Database | Tools | Framework |
|---|---|---|---|---|---|---|
| Web Developers | HTML-CSS, JavaScript, Java, PHP, Python | Front-End Developer, Back-End Developer, Full-stack | Design UI-UX | SQL Server, MySQL, MongoDB | APIs-Rest, Git, Redux, jQuery | Laravel, Angular, Angular JS, Vue JS, Bootstrap, Node JS |
| Computer System Analysts | | System Architects | Data analysis, business analysis, system analysis, design system | SQL Server | Agile Software, Microsoft Excel, SQL-Tableau | |
| Software Developers, and Quality Assurance, and Testers | HTML-CSS, JavaScript, Net, Golang, Python, PHP, Java, | Software Engineer, Senior Engineer | Develop software, design application, test automation, quality assurance | MySQL, PostgreSQL, MongoDB | Agile, APIs-Rest, IOS, Android | Node JS, React JS, Spring |
| Information Security Analysts | Python | Cyber security | Control and monitor risk infrastructure, and data security, develop standard security | | LINUX base, firewall | |
| Computer Programmers | Java, Golang, PHP, ASP.Net, HTML-CSS, JavaScript, Python | Programmer, Developer, Software engineer | Design and develop a program | SQL Server, NoSQL, PostgreSQL, | APIs-Rest, | Node JS, Spring JS, React JS, Vue JS |
| Computer Support Specialists | .Net | IT Support | Test and evaluate computer systems for a client, Service Level Agreement, Helpdesk for problem service | Not available | LINUX, firewall, | |
| Database Administrators and Architects | | | Design and develop database, maintenance and backup database, control access rights | SQL, Oracle, NoSQL, MySQL, PostgreSQL | SSIS, OLAP | |
| Computer and Information Research Scientists | Python | Data Science | Data analysis, design, and experiment using Machine Learning technique | SQL | | Machine Learning |
| Computer Network Architects | .Net | Network Engineer | Design infrastructure network, configure LAN and WAN | | CISCO, Firewall, LINUX, Azure, AWS | |
| Network and Computer System Administrators | | Network Engineer Staff | Maintain hardware and network infrastructure | | CISCO, Firewall, LINUX, VMWare | |

and computer system administrator, which do not have a map of elective subjects, indicating that these two jobs do not have subject specialization. From the researcher's analysis results, it was concluded that the two jobs had sufficient learning

material through mandatory subjects in the study program curriculum.

### 3) PERSONALITY TYPE (MBTI)

Personality type can be used to predict a personal preferences which can be a success factor in his career [9], [10]. The compatibility of personality types is an important factor in achieving good performance and satisfaction for someone who is pursuing a job [6], [8]. The study also stated that there are various ways to measure interest compatibility through the index of personality fit and match. In a literature study conducted by [12], internal factors including personal interest, personal efficacy, expected salary, and professional development opportunities are important factors in choosing a person's career in life. But personal interest is the main factor influencing the career choice of young people in their career decision-making. Personality refers to the character played by a person, or the character displayed by that person in the outside world. Research on personality is useful, among other things, for providing recommendations for products, services or choosing someone to occupy a particular career [48], [49], [50].

The phase of this module is presented in Fig. 4. The IT jobs database revealed from the IT job profile phase was then analyzed and extracted with the Myers-Briggs Type Indicator (MBTI) approach using Grounded Theory. The MBTI is a questionnaire-based psychological test widely used in education and industry [51]. The MBTI can be used as a type of indicator to map a person's career. Several studies related to the performance in computer programming [52] and text classification [49] using MBTI are interesting. The MBTI is designed with a varied and broad scale to classify a person's personality to measure their psychological interest in seeing the world and making decisions [49]. The MBTI approach can divided into four classes [49].

1. Extraversion(E) vs introversion (I). This class describes how a person looks from the outside. Extraverts talk a lot and enjoy social interaction with their environment, while introverts tend to be closed and happy to spend time for themselves or a small group of people.

2. Sensing(S) vs intuition (I). This class shows how a person perceives the information. People with a Sensing personality like to involve themselves in new experiences so that they can be directly involved in the field and learn from that experience. Intuition is a characteristic of someone who spends a lot of time imagining and thinking abstractly.

3. Thinking(T) vs feeling (F). This class shows how decisions are made. Thinking is the personality of a person who makes decisions based on the logic of thinking, whereas people with a feeling personality make decisions that are dominated by feelings.

4. Judging(J) vs perceiving (P). This class shows an individual's orientation towards the outside world. Judging personality is firmer in its stance, while perceiving is better able to adapt to new things.

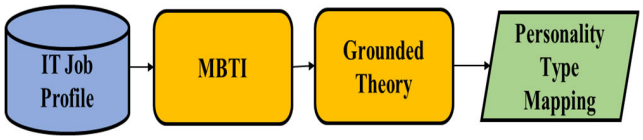


**FIGURE 4.** Personality type's mapping phase of CPRM based on EDM-GT model.

**TABLE 4.** Personality type mapping of EDM-GT model.

| Job Title | Personality Type |
|---|---|
| Web Developers | INFJ, ENTJ, ENFJ, ENFP |
| Computer System Analysts | ENTP, ESFP |
| Software Developer Quality Assurance | INFJ, ISTJ |
| Information Security Analyst | ISTJ |
| Computer Programmers | INTJ |
| Computer Support Specialists | INFP, ISFP, ESTP, ESFP |
| Database Administrator and Architects | ISTJ, ESTJ |
| Computer and Information Research Scientist | INTJ, INFP, ISTJ, ISTP |
| Computer Network Architect | INTJ, ISTJ |
| Network and Computer System Administrator | ISTP, ISFJ, ESTJ, ESTP, ESFJ |

MBTI approach forms 16 personality types known as ENFJ, ENFP, ENTJ, ENTP, ESFJ, ESFP, ESTJ, ESTP, INFJ, INFP, INTJ, INTP, ISFJ, ISFP, ISTJ, and ISTP.

As presented in Fig. 4, the IT job profile was analyzed and extracted by three psychologists and professionals through FGD in personality mapping using MBTI tools and the grounded theory approach. The summarization of this FGD was processed via Nvivo 12 software and generated a personality-type map. The MBTI test is carried out by giving 52 question items to respondents. Validity and reliability tests for question items have been measured using Pearson correlation and processed by SPSS software for each aspect of personality with an average value of 0.703 (high). Personality type mapping was revealed in this phase as shown in Table 4.

The function required by jobs related to developing systems or programs such as a developers and designers, is intuitive thinking, because he sees things from the big picture. Introvert personality types focus more on objects and work independently, whereas extroverts focus more on how to benefit the user. A daily activity or routine must have a judging indicator, and an exploratory activity usually has a perceiving indicator.

## D. RECOMMENDER ENGINE

After constructing the EDM-GT model, a recommender engine was designed. We used a personalized-Naive Bayes

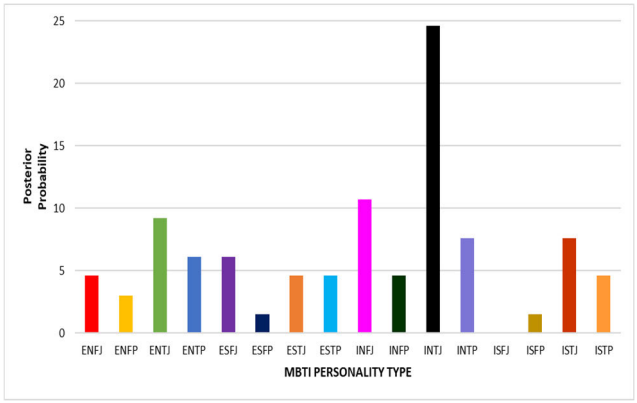


**FIGURE 5.** Personalized Naïve Bayes algorithm of career path recommendation model based on MBTI approach.

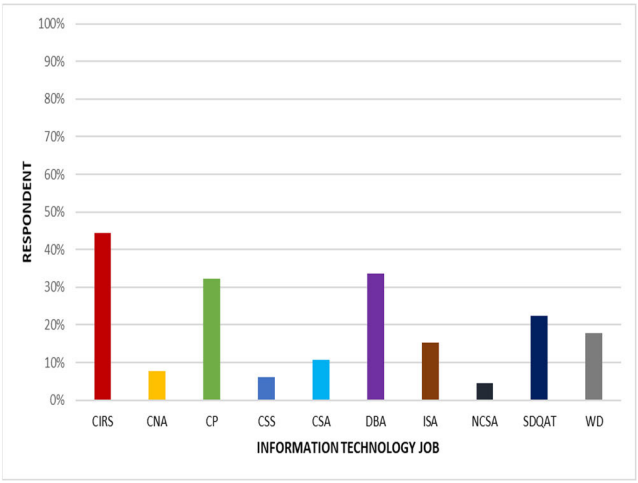


**FIGURE 6.** Information technology job preferences based on [53].

(p-NB) algorithm to support the EDM-GT model mapping, which is the main component of the framework. p-NB is a classification technique used to provide job recommendations and support subjects based on students' personality types. The value of the prior probability and posterior probability value in the MBTI category uses the number of answer options divided by the number of questions as shown in Formulas (1) and (2).

$$P(Ci) = Ni/N \tag{1}$$

where the prior probability ($P(Ci)$) calculated by dividing the number of correct answers (N$i$) by the total number of questions (N).

$$P(Ci|X) = P(X|Ci) * P(Ci) \tag{2}$$

meanwhile, calculating the posterior probability ($P(Ci|X)$) value for each MBTI category uses the multiplication of each personality type value ($P(X|Ci)$).

The experimental data of 65 students using CPRM and the results in Fig. 5 show the posterior probability values. ESFP and ISFP had the smallest posterior probability value (1.5), which means that only one in 65 students had this personality type and preferred computer programmer or computer support specialist jobs. Meanwhile, INTJ has a posterior probability value spread of 24.6, which means that there are 15 students who prefer Computer and Information Research Scientists, Computer Programmers, or Database Administrators and Architects jobs. Fig. 6 shows that CIRS jobs have the highest preference for 44.41% of the students who use CPRM. Meanwhile, only 4.6% of the students preferred NCSA jobs.

## IV. CPRM IMPLEMENTATION AND EVALUATION

This section explains the implementation process of the CPRM and the evaluation of the quality of the recommended items.

### A. CPRM IMPLEMENTATION

The CPRM's design is a web-based application that can be easily used by college students. The objective of the design is to have clear views of the data collection and recommendation processes, as shown in Fig. 7 and Fig. 8. The front-end of CPRM was implemented based on the ReactJS framework, and the Golang programming language was implemented as the back end.

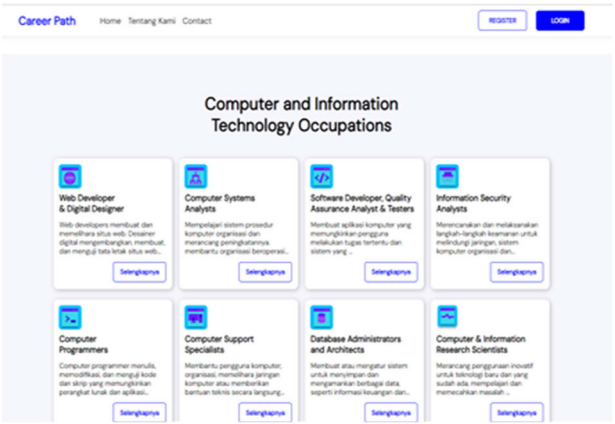


**FIGURE 7.** Interface of main menu of career path recommendation model.

The prototype system was designed based on a personalized CPRM framework. A cloud-based structure is used to organize all the modules using open-source frameworks. The first step of CPRM's application is asking the student to answer the MBTI test to analyze the personality type. The MBTI consists of 52 questions and should be filled to 100%. The application processes the MBTI test by applying the p-NB algorithm, which implements the EDM-GT model. The output of CPRM application is a recommendation system that includes jobs and subjects suitable for a user's personality type. The recommender engine provides job and subject recommendations to students with clear results. The CPRM was designed to be user-friendly and secure personalized information by implementing the registration stage as the authorization. The application can be easily developed to provide recommendations for other disciplines by expanding the p-NB algorithm or others.

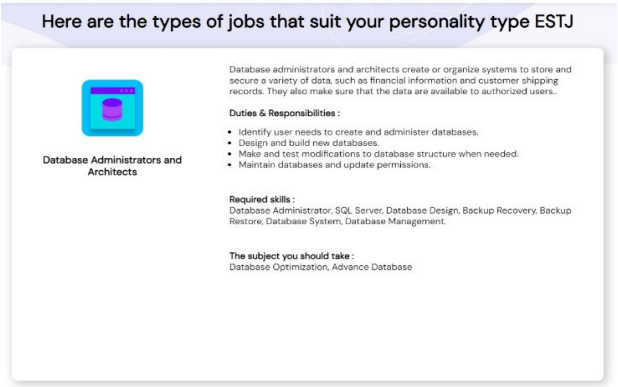


**FIGURE 8.** Output interface of career path recommendation model.

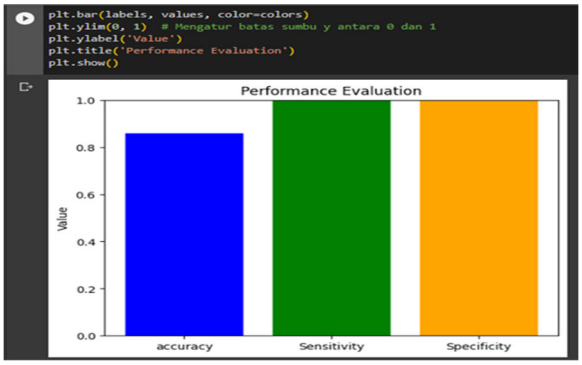


**FIGURE 9.** Accuracy and usage prediction of career path recommendation model.

### B. QUALITY OF RECOMMENDATION ITEM'S EVALUATION

The evaluation section was to determine whether the proposed model is well accepted by users and has proportional accuracy. The respondents were computer science students from private university in Indonesia. To derive the association between computer science disciplines and personality types, a research analysis was conducted on a sample of 104 respondents to evaluate accuracy and usage prediction. This study evaluated the model by measuring the quality of the recommended items [1], [54] participated by 65 respondents. The items referred to in this study were the jobs and subjects recommended in this model. The questionnaire was evaluated by compiling questions based on the guidelines and principles according to Ian Brace regarding the preparation of an effective questionnaire in a study [55]. The questionnaire was in the form of questions and closed statements using a Likert scale consisting of 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. Model evaluation was performed using six of the ten measurement categories defined in [54]. The six categories were prediction accuracy, usage prediction, novelty, diversity, coverage, and serendipity.

#### 1) ACCURACY AND USAGE PREDICTION

The prediction accuracy was revealed by measuring the accuracy performance of the algorithms and models using Google Colab tools. To measure accuracy, the highest prior probability value of 16 personality types obtained from 104 CPRM test results data was used by dividing 80% into training data and 20% into testing data using the train_test_split function from the scikit-learn (sklearn) library. An accuracy of 85% is achieved for the proposed model. Usage prediction measurements were performed using specificity and sensitivity metrics in a confusion matrix [32]. Specificity and sensitivity values were obtained with specificity and sensitivity of 100% or equal to 1. The accuracy and usage predictions are shown in Fig. 9.

#### 2) COVERAGE

Coverage measurement uses two metrics; user satisfaction with the quality of recommended items and accuracy of recommended items [1].

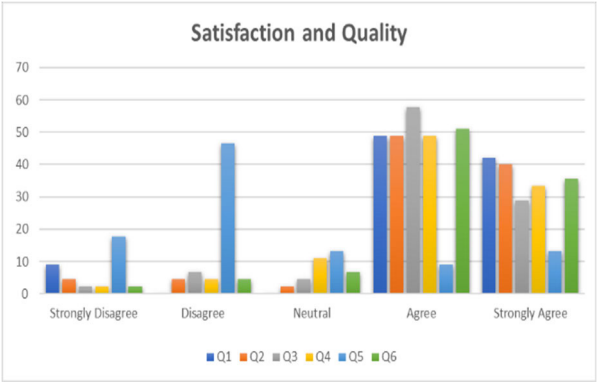


**FIGURE 10.** Coverage measurement of user satisfaction with the quality of recommended job and subject.

User satisfaction regarding the quality of recommended items (job and subject) has six questions as follows:

*Q1: I am satisfied with this application.*

*Q2: I am convinced in the jobs and subjects recommended to me.*

*Q3: I will like the job and the subject recommended to me confidently.*

*Q4: This recommendation system makes me more confident about my decisions/selections.*

*Q5: Recommended job and subject make me confused about the choice I should make.*

*Q6: This recommendation system is trustworthy.*

Fig. 10 shows the coverage of the quality of the recommended job and subject. The questionnaire concluded that 91% of respondents were satisfied with the recommendations they received. This recommendation helped students obtain suitable recommendations. Moreover, 82% of students agreed that the recommendation system had helped them make the right decisions by giving them an appropriate choice.

The accuracy of the job and subject recommended to students matched their personality type was evaluated by this metric. The next question reveals whether the model recommends good suggestions to help students' decision-making. The accuracy questionnaire was as follows.

*Q1 The jobs and subjects recommended to me matched my personality type.*

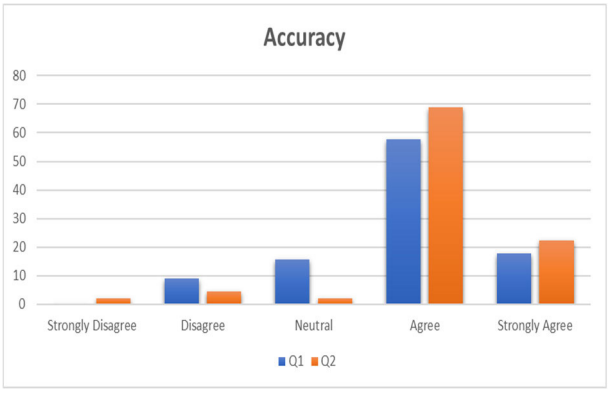


**FIGURE 11.** Accuracy of recommended job and subject.

*Q2 This recommender system gave me right suggestions.*

Fig. 11 shows the accuracy of the recommended job and subject. 83% of the respondents stated that recommended jobs and courses matched their interests and personality types and provided good advice.

### 3) NOVELTY

Novelty was measured using two metrics, familiarity and novelty. Familiarity explains how well respondents know about some of the recommended jobs and subjects. CPRM uses website-based recommendation techniques to recommend the most relevant jobs and courses to the respondents. The question was, ''Are the recommended jobs and subjects familiar to you?'' The results of the questionnaire as shown in Fig. 12, showed that 93% had received recommendations that included familiar jobs and subjects, and 7% of the respondents said the jobs and courses were something new.

Novelty measures the extent to which the recommended item is something new to the user [56]. To measure the novelty of this model, the following questions were asked:

Q*1: The job and subject recommended to me are novel.*

*Q2: This recommender system helped me disover a new job and subject.*

### 4) DIVERSITY

Diversity refers to the dissimilarity between recommended items. Career Path primarily recommends jobs and subjects based on filtering the required skills and learning materials, which measure the similarity between user profiles, jobs, and subjects. The question of whether the recommendation has various items is:

*Q1: The job and subject recommended to me are diverse.*

The results in Fig. 13 shows that more than 93% of the recommended jobs and subjects are diverse.

## V. COMPARASION

As the comparisons of the study with previous studies, we state that:

1. It uses mixed methods of quantitative and qualitative data to better understand research problems and propose a proper solution. Quantitative data were processed using the EDM technique and qualitative data were processed using the GT approach. Most previous research has used quantitative data in the career and subject recommendation research field.

2. The validation of model involved IT professionals and psychologists to encourage students' preferences through the MBTI approach in Indonesia.

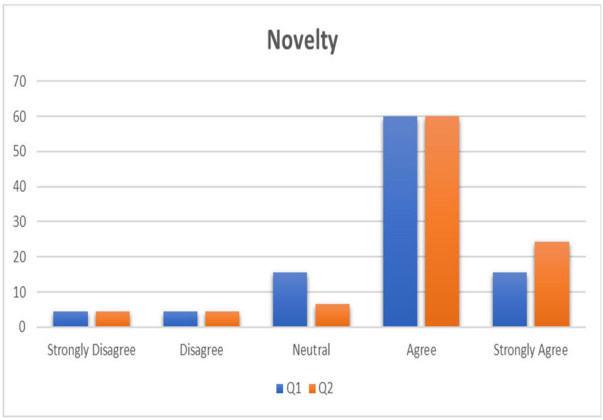


**FIGURE 12.** Novelty metrics of career path recommendation model.

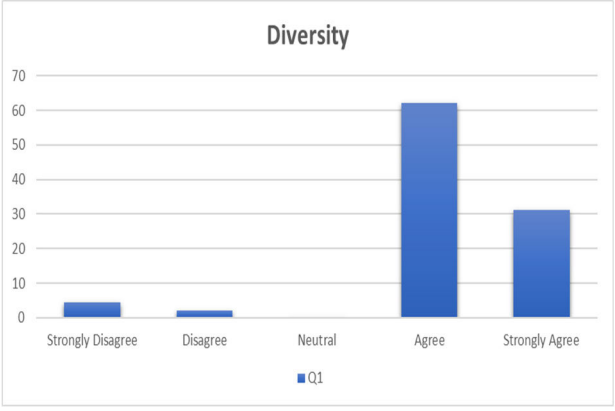


**FIGURE 13.** Diversity metrics of career path recommendation model.

## VI. CONCLUSION, LIMITATIONS, AND FUTURE WORKS

Our proposed model makes an essential contribution as a comprehensive framework using mixed methods that combine educational and psychology fields through educational data mining and grounded theory (EDM-GT) techniques to personalize students' information. The personalized Career Path Recommendation Model (CPRM) is designed to help computer science students choose their career paths according to their personality type. Job recommendations through industrial needs match the learning materials in university curricula. This model has some benefits, such as automatic academic advisors as guidance for students to initiate their career path and can be used to evaluate the learning structure of higher education programs to fulfill industry needs. The design of CPRM is based on a personalized-Naive Bayes

(p-NB) algorithm with three primary sources: subject info, career info, and personality type information. A research analysis was conducted on a sample of 104 respondents to determine the association between computer science disciplines and personality types. The experiments proved that the CPRM is a useful tool for students to make academic recommendations, and the proposed model has great student satisfaction and accuracy. The EDM-GT framework helps the system provide comprehensive recommendations to students by integrating data from various sources. This personalized recommendation model improves the ability to reveal knowledge of the recommended jobs and subjects and has been validated by involving expert judgment as well as IT professionals, and psychologists. The researcher noticed that the new career path recommendations model with the EDM-GT-based approach can optimize time processing in finding information regarding a suitable career matched with student interest. Moreover, the integration of the IT job profile, subject mapping, and personality type mapping can improve the accuracy of the recommendation and user satisfaction. This model addresses the user problem in the educational recommendations by incorporating quantitative and qualitative methods into the proposed framework. It was found that mapping to link the subject profiles and student profiles with the job profile helped to provide comprehensive knowledge. It successfully brought an interesting dimension to education domain and industrial view.

Some limitations of our model include:

1) Sometimes, the web scraping process was not perfect causing irrelevant and missing data. Difficulties in the text preprocessing step cause reduced analysis results.

2) The subjective view may be generated from the proposed model since certain assumptions about the data and underlying process.

3) The proposed model is a new one in Indonesia, so we can't compare it with a similar model.

Recommendation for other researchers in this field:

1. Absorbing a new dataset from various sources with tagging to facilitate the text preprocessing stage.

2. To eliminate the subjectivity of the model, focus group discussions can be improved by involving IT companies and the government to improve research results sustainably.

In the future, we will:

1) Provide heterogeneous data sources by absorbing more jobs through LinkedIn platforms and students' academic performance as personality information.

2) Construct an intelligent recommendation model by exploring student behavior and learning style in the recommendation process.

3) Ensemble machine learning integrated with a recommendations model can be further developed to enrich future model.

**Author Contributions**: Conceptualization, P.C.S. and H.L.H.S.W.; methodology, A.R. and P.C.S.; software, P.C.S.; validation, W.B., H.L.H.S.W. and A.R.; resources, P.C.S.; writing—original draft preparation, P.C.S.; writing—review and editing, P.C.S.; visualization, W.B.; supervision, W.B. H.L.H.S.W. and A.R. All authors have read and agreed to the published version of the manuscript.

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