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The Decision-Support Modeling with Fuzzy Analytic Hierarchy Process (AHP) to Determine the Career Path for Bachelor Informatics Students

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Abstract

The pursuit of success in one's chosen profession is a universal aspiration that requires individuals to engage in competition, not just domestically but also internationally, particularly in today's era of globalization. The rapid advancement of technology presents both opportunities and challenges, necessitating proactive management to achieve professional success. In the field of Informatics Engineering, there is a wide range of professional pathways, each offering unique opportunities and requiring distinct skill sets. For university graduates, it is crucial to have a comprehensive understanding of the specific requirements and demands associated with various job paths to make informed decisions. This knowledge enables them to select a professional route that aligns with their individual aspirations and goals, thereby avoiding potential discontent in their chosen career. Lack of knowledge or awareness during the decision-making process can negatively impact productivity and overall performance. There is a growing demand among university graduates, especially at the undergraduate level, for career-related information. This has led to heightened competition among graduates in terms of skills, knowledge, and availability. To effectively navigate this competitive landscape and engage in meaningful competition with fellow graduates, individuals must possess a comprehensive understanding of their desired career trajectory. To address these challenges, the Decision Support Model (MPK) can be utilized, employing the Fuzzy Analytical Hierarchy Process methodology. This approach considers four primary criteria—Financial Compensation, Non-Financial Compensation, Soft Skills, and Hard Skills—each with several sub-criteria. These criteria are evaluated based on the perspectives of certified graduates of Informatics Engineering and industry specialists. The study successfully identified the primary criteria influencing career decisions, such as job conditions, incentives, and prospects. It also highlighted the most favorable career path, with the role of a Data Analyst being identified as particularly promising. This career path involves roles within the field of Informatics Engineering that focus on processing data according to specific requirements, highlighting the importance of understanding the evolving landscape of technology and its impact on professional opportunities.

Keywords:

Fuzzy AHP;
Decision Support;
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1- Introduction

The aspiration for professional success is a universal desire. In the context of globalization, the level of competitiveness within the professional realm is intensifying. This competition extends beyond domestic boundaries, as individuals from foreign countries also actively engage in pursuing their career aspirations. Consequently, the attainment of professional achievement has grown progressively more arduous. Nevertheless, the definition of success in a professional career varies among individuals. Individuals who have attained a specific threshold of financial stability and have established a vocation that aligns with their personal preferences might be considered to have achieved success in their professional endeavors [1]. Furthermore, according to Haenggli & Hirschi [2], the concept of career success can

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be categorized into two distinct dimensions: subjective and objective. From a subjective standpoint, the measure of success in a career is contingent upon an individual's personal level of contentment. Conversely, from an objective standpoint, success is determined by the monetary compensation received by the individual. Among the various conceptualizations of job success, one might attain success by selecting a vocation that aligns with their individual aptitudes, passions, and distinctive attributes [3]. A career refers to the occupation that an individual pursues throughout their lifetime, encompassing a range of experiences and a succession of employment opportunities aimed at furthering their personal and professional growth [4]. Therefore, a viable approach to attaining professional success is selecting an occupation that aligns with an individual's aptitudes, passions, and unique attributes.

In the contemporary period characterized by digital advancements, the domains of technology and science are seeing quick and significant progress. The proliferation of technology and scientific advancements has presented a conundrum for recent graduates in their decision-making process over their career trajectory. Despite the abundance of prospects, numerous obstacles must be confronted, hence complicating the selection process [5]. In addition to the challenge of selecting a suitable career trajectory, a significant number of individuals encounter the necessity for course correction in their chosen professional pursuits. According to the findings presented in Rene & Wahyuni [6], a significant proportion of employees, specifically 73 percent, express dissatisfaction with their current employment. This discontentment has been observed to have adverse effects on production levels as well as impede the potential for professional growth and advancement. According to the study conducted by Sultana & Kawsar [7], several factors exert an effect on an individual's decision to choose an inappropriate career path. These elements encompass peer influence, limited understanding and exposure to the chosen sector, insufficient consultation with parents, friends, and educators, as well as personal aspirations for societal recognition.

Challenges associated with career decision-making are encountered throughout various professional domains, including the subject of Informatics Engineering. The field of Informatics Engineering in Indonesia has been experiencing consistent growth on an annual basis. Based on the findings of Pordelan & Hosseinian [8], the incorporation of Information Technology has emerged as an indispensable requirement for all institutions, encompassing those situated within the Indonesian context. The growing advancements and demand in the field of Informatics Engineering have resulted in a corresponding expansion of work opportunities within this domain. Consequently, anyone seeking to pursue a career in Informatics Engineering must possess a comprehensive awareness of the various specializations available in order to make informed decisions. Despite the growing demand for professionals in the field of Informatics Engineering, it is projected that the supply of workers would surpass the demand by the years 2021–2025 [9, 10]. This phenomenon engenders a more challenging competitive landscape, leading to heightened competition for skills and necessitating a more discerning approach to career selection. Selecting a career trajectory presents challenges as it necessitates not only comprehending the intricacies of the chosen profession but also acquiring knowledge on the array of career possibilities and the requisite skill sets.

The availability of a diverse range of employment opportunities, the multitude of elements that impact the decision-making process in career selection, and the dynamic nature of the information technology landscape present considerable difficulties in making an informed choice on one's professional path. It is recommended to utilize the Decision Support Model as a means to address this issue, as this model has the capability to aid in the selection and provision of career options. By employing this model, the chosen career options can be more refined and more equipped to evaluate prospective candidates. The study conducted by Myla et al. [11] employs a Decision Support Model to assist students in selecting academic disciplines, namely those connected to computer science and computer/electronics. The model incorporates a combination of fuzzy logic techniques to enhance the decision-making process. The study conducted by Qamhieh et al. [12] aimed to assist senior high school students in selecting engineering courses that align with their academic performance and personality type. This was achieved through the development of a Decision Support Model utilizing the fuzzy logic method. In the study conducted by Santony et al. [13], the Analytical Hierarchy Process (AHP) methodology was employed to ascertain the selection of personnel for promotion, taking into consideration several variables such as planning, teaching, evaluating, and learning.

The utilization of the Decision Support Model in research has proven to be beneficial in the assessment of career routes. This model has been particularly effective in guiding career decisions for high school students, aiding in the selection of appropriate courses, as well as facilitating the identification of employees suitable for promotion. Furthermore, the Decision Support Model can also provide assistance in the process of job selection. The study undertaken by Gati & Tal [14] involved the development of a Decision Support System that utilized the Simple Additive Weighting approach. This system aimed to identify suitable career paths for graduates of Information Systems by considering the value profile of their coursework within the Information Systems curriculum. The Decision Support Model is employed in research undertaken by Li & Li [15] to ascertain suitable employment opportunities during summer holidays. In this study, the proposed methodology entails the integration of the Fuzzy approach and the Analytical Hierarchy Process (AHP), both of which have been employed in prior research endeavors. The integration of these two approaches seeks to mitigate the inherent subjectivity associated with the Analytic Hierarchy Process (AHP) method [16]. The Decision Support Model is designed to aid Informatics Engineering students in making informed decisions regarding their career trajectory by helping them identify job opportunities that align with their own interests and skill sets.

Typically, firms require a minimum educational attainment of a bachelor’s degree for job vacancies. Furthermore, there was a notable rise in the number of undergraduate graduates, from 874,536 in 2018 to 1,200,105 in 2019. However, this figure saw a decline to 1,042,844 in 2020. Nevertheless, there was a subsequent increase in 2021, with the number of undergraduate graduates reaching 1,158,766 [17–20]. This phenomenon indicates a rise in rivalry among college graduates, necessitating a prior comprehension of the career trajectories they intend to embark upon at the culmination of their educational pursuits.

In recent years, the Informatics Engineering study program has gained recognition among new students in Java, Kalimantan, and Nusa Tenggara islands [19]. The Informatics Engineering study program's level of popularity can be influenced by a multitude of elements, including but not limited to salary, career possibilities, social aspects, and several other factors [5, 21]. The phenomenon of popularity is occasionally coupled by a lack of awareness regarding the chosen professional trajectory, resulting in individuals ultimately selecting a career route that diverges from their personal interests and aptitudes. This study focuses on the alumni of the Bachelor of Informatics Engineering program.

University graduates who possess excellent accreditation are generally seen as having greater potential and competence compared to their counterparts who do not possess such accreditation. Opinions may be formed due to the presence of accreditation, which serves as a quality benchmark for institutes or study programs, ensuring their adherence to established criteria. Consequently, institutes or study programs that receive higher levels of certification are deemed to possess greater quality facilities [22–24]. The presence of institutional or program-owned facilities has been shown to have a positive impact on students' academic performance and competency [2]. This study aims to depict pupils who possess educational excellence that is acknowledged by both society and industry.

2- Related Works

2-1- Career Path Selection System using Fuzzy Logic

The study undertaken by Myla et al. [11] aimed to build a decision support model that assists students in selecting an academic branch, hence guiding them towards a career path aligned with the recommended academic discipline. This research provides evidence supporting the efficacy of the Decision Support Model in facilitating option selection, as well as the utilization of questionnaire data as input for the model. The research employed a methodology based on the utilization of fuzzy logic. A study conducted by Comendador et al. [25] has devised a Decision Support System that utilizes the Fuzzy Logic approach to address challenges associated with selecting academic majors. Based on the findings of this study, it can be inferred that Fuzzy Logic is a viable approach for facilitating decision-making processes. Furthermore, this study elucidates that Fuzzy Logic is a methodology that is adept at managing data characterized by uncertainty. The model developed is predicated upon the utilization of a personality assessment and a knowledge assessment within the realm of STEM (Science, Technology, Engineering, and Mathematics).

2-2- Career Path Selection System Using Analytical Hierarchy Process

The study conducted by Gestiada et al. [26] presents a Decision Support Model that employs the Social Cognitive Career Theory approach for parameter determination and utilizes the Analytic Hierarchy Process (AHP) for decision-making purposes. This study demonstrated the applicability of the Analytic Hierarchy Process (AHP) in the context of multi-criteria decision-making. The study conducted by Mainingsih & Hamka [27] examines the development of a Decision Support System (DSS) for job selection, focusing on factors such as compensation, career trajectory, amenities, and work environment. This research demonstrates the applicability of the Analytic Hierarchy Process (AHP) in job selection, utilizing the specified criteria.

A study conducted by Santony et al. [13] developed a Decision Support System that uses the Analytic Hierarchy Process (AHP) to identify optimal candidates for career progression or to match specific positions with the most suitable personnel. Based on the findings of this study, it can be inferred that the Analytic Hierarchy Process (AHP) methodology is effective in ascertaining the optimal selection among a range of pre-established alternatives [28]. The study employed the criteria of Planning, Teaching, Evaluation, and Learning, yielding an accuracy rate of 86.67%.

2-3- Career Path Selection System Using Fuzzy Analytical Hierarchy Process

A study was undertaken by Saha et al. [29] with the objective of adopting the Fuzzy Analytic Hierarchy Process (AHP) method to address the issue of selecting majors within the Information Technology (IT) field. According to the findings of this study, it has been suggested that Fuzzy Analytic Hierarchy Process (AHP) has the potential to effectively address the inherent ambiguity associated with decision-making. Furthermore, this study provides evidence to support the utilization of the Fuzzy Analytic Hierarchy Process (AHP) as a viable approach for decision-making in option selection.

2-4- Comparison Between AHP and Fuzzy-AHP

The study undertaken by Raco et al. [30] aimed to compare the Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP) methodologies in identifying the crucial soft skills required in the context of the fourth industrial revolution. This research leads to the conclusion that the assessment of ambiguity in human thinking is a significant aspect to consider. The findings of this study also indicate that the Fuzzy Analytic Hierarchy Process (AHP) technique necessitates a greater amount of computational time yet yields superior levels of accuracy when compared to the AHP method.

The study conducted by Chan et al. [31] involved a comparison of the Fuzzy AHP and AHP approaches. Based on the findings of this study, it can be inferred that there is a lack of substantial distinction between the AHP method and the Fuzzy AHP method. The utilization of the Fuzzy Analytic Hierarchy Process (AHP) is more advantageous in cases where certain established criteria exhibit several equally significant criteria or possess a numerical scale of 1. Furthermore, the utilization of Fuzzy Analytic Hierarchy Process (AHP) has the potential to mitigate subjectivity in the process of assigning weights to criteria.

3- Material and Methods

3-1- Excellent Accredited Informatics Engineering

Informatics engineering is an academic discipline wherein students engage in the study and practical application of computer science principles and methodologies. This field includes the creation, testing, and evaluation of operating systems, software, and computer performance, with the aim of addressing various computational challenges [32]. As noted by Caspersen et al. [33], the field of Informatics Engineering education, commonly referred to as Computer Science, has experienced global development. Consequently, it is imperative to acknowledge the significance of informatics education in order to optimize the accrued advantages. The term "informatics" was initially coined by Karl Steinbuch, a German computer scientist, in 1957. This term encompasses a range of disciplines, such as information science, information systems, information processing, and other interconnected topics.

Accreditation refers to the process of evaluating and assessing a university or study program in order to determine its quality based on defined standards, logical reasoning, and expert opinions [34]. The rankings that have been accredited as a consequence of the accreditation conducted by BAN-PT are as follows:

The accreditation process involves assessing A, B, and C based on seven standard accrediting instruments. Additionally, accreditation is determined as *Excellent*, or *Good* utilizing the IAPS 4.0 and IAPT 3.0 frameworks.

Based on the available evidence, it can be inferred that Informatics Engineering students who possess the distinction of being accredited as excellent are those who are pursuing their studies in the field of Informatics Engineering at a university that has received an A or higher accreditation from the National Accreditation Board for Higher Education (BAN-PT). This study explores the potential for proficient informatics engineering graduates to effectively utilize the developed model.

3-2- Informatics Engineering Career Path

Having a background in the IT field will open up career opportunities in the IT field. Based on data from [35], jobs in the IT field that are on the rise in 2021 are as follows:

1. ***Data Analyst***

   Due to technological developments, companies are required to process many data. So it takes a role to process, analyze and store data. Jobs grouped into this group include Business Operations Analyst, Business Development Analyst, Analysis Specialist, Business Analyst, Data Analyst, and Data Scientist.

2. ***Software Developers***

   This software developer is needed because companies will always adopt new technology. Jobs grouped into this group include Web Developer, System Analyst, Mobile Application Developer, Full Stack Engineer, Frontend Developer, and DevOps Consultant.

3. ***Technology Support***

   Software developers focus on the software section, while technology support focuses on the hardware section. Jobs grouped into this group include IT Support Technician, Network Administrator, System Administrator, Computer Technician, and Technical Support Engineer.

4. ***Cyber Security***

   Security also needs to be improved with the development of technology and data. The challenge for governments and companies is to improve their data security so that the demand for cyber security increases. Jobs grouped into this group include Cyber Security Analyst, Cyber Security Specialist, Cyber Security Consultant, and Information Security Specialist.

3-3- Decision Support Model

The Decision Support Model is a system that plays a significant part in the evaluation of solutions, hence enhancing the quality of ensuing choices [36]. As stated by the source cited as Yuhelmi et al. [37], the Decision Support Model is characterized as a system that facilitates problem-solving by aiding in decision-making and offering information or recommendations for decision-making processes. The inception of the Decision Support Model may be traced back to 1970, when it was initially introduced by Scott Morton. The problem-solving process is facilitated by the utilization of specific data and models in this system [38]. Decision support models may not always yield completely accurate outcomes due to their reliance on a technology that emulates human decision-making processes [39]. Nevertheless, as stated by Amos Pah [40], the utilization of Decision Support Models remains advantageous in the decision-making process. This is attributed to the system's ability to generate choice outcomes that are more objective, rational, and responsible, owing to its foundation on logical considerations.

According to Utama [41], the stages of research in the Decision Support Model domain are described:

- ***Case Analysis***

  Analyze and understand the case to be raised. The level of understanding and knowledge of the case will affect the quality of the model.

- ***Decision Analyzing***

  It analyzes decisions taken from cases that have been analyzed to be resolved. This is done so that the resulting decisions are not just any decisions but can be justified.

- ***Parameterizing***

  The parameters to determine the decision must be analyzed and related to the model. The meaning, definition, and relationship between parameters must be understood when analyzing them. To do parameterizing, you can do deep analysis or use influence diagrams.

- ***Data Collection or Data Generating***

  After the parameters have been set, the next step is to find the data to be used. If the data to be used is owned by a company, then data collection is carried out, whereas if the data is still scattered or requires data from various sources, then data generating is carried out. The process of collecting, cleaning, normalizing data, and so on is also carried out.

- ***DSM Constructing***

  The stage of building a decision support model. The input, process, and output processes must be visible at this stage.

- ***Decision Proposing***

  The stage where the model has been running recommends one or various options for the case at hand.

- ***Model Verifying and Validating***

  Verifying means assessing the correctness of the model that has been made, and validating means assessing the correctness of the data used. At this stage, the model will be checked to see whether it is running as it should. The purpose of this stage is that the model that has been made can be justified.

3-4- Fuzzy AHP

Fuzzy AHP is a combined method between AHP that was developed with fuzzy logic, wherein the AHP scale is combined into a fuzzy triangular scale [42, 43]. According to Hermansyah [16], with Fuzzy AHP, the drawbacks of the AHP method are subjective criteria that produce uncertainty values that can be covered. The steps taken in applying this method are more or less the same as the usual AHP method. The thing that distinguishes Fuzzy AHP from ordinary AHP is the pairwise comparison scale (Table 1). According to Mohammed et al. [44], the scale was developed based on the numbers in the fuzzy triangle.

Table 1. Fuzzy AHP Comparison Scale

Fuzzy Value	Verbal Judgement
(1, 1, 3)	Equally Important
(1, 3, 5)	Moderately more important
(3, 5, 7)	Strongly more important
(5, 7, 9)	Very strongly more important
(7, 9, 9)	Extremely more important

3-5- Proposed Methods

3-5-1- Analyzing Decision Alternatives

When constructing a Decision Support Model, it is imperative to identify an alternative decision or choice that aligns with the intended objective of the model (Table 2). The present study explores alternative career paths in the field of Informatics Engineering, as outlined in EduSpiral [35]. The study conducted by Kumalasari & Susanto [45] utilized the same professional domain to construct a career suggestion system that relied on the abilities documented on LinkedIn. Consequently, the present investigation presents a tabular representation of the chosen career options within the realm of Informatics Engineering.

Table 2. Decision Alternatives

Decision Alternatives	Consist of
Data Analysts	Business Operations Analyst, Business Development Analyst, Analysis Specialist, Business Analyst, Data Analyst, Data Scientist
Software Developer	Web Developer, System Analyst, Mobile Application Developer, Full Stack Engineer, Frontend Developer, DevOps Consultant
Technology Support	IT Support Technician, Network Administrator, System Administrator, Computer Technician, Technical Support Engineer
Cyber Security	Cyber Security Analyst, Cyber Security Specialist, Cyber Security Consultant, Information Security Specialist

3-5-2- Creating Parameters

The subsequent stage involves establishing the criteria factors that exert influence on the process of decision-making. The determination of parameters is based on a comprehensive review of relevant literature conducted in the preceding chapter. The present study focused on conducting a literature review to examine the research pertaining to the factors that influence students' decision-making process in selecting their professional options. Furthermore, a comprehensive review of the existing literature was conducted to examine the many characteristics that firms consider when selecting potential candidates for employment. The factors that influence the choosing of a student's career path are derived from the findings of a study conducted by Maulindar & Cahyani [46]. These factors can be categorized into two main dimensions: financial compensation and non-financial compensation (Table 3). As stated by Nur Irawan [47], the primary form of influential financial remuneration is the pay and incentives offered by the organization.

Table 3. Main Criteria

Criteria	Sub Criteria	Definition
Facility	Financial Compensation	Benefits provided by the company to employees in the form of money
	Non-Financial Compensation	Benefits provided by the company to employees in a form other than money
Ability	*Soft Skills*	Ability related to nature and social interaction
	Hard Skills	The technical skills needed to do a job

In addition, it is worth noting that non-financial remuneration includes factors such as working conditions, employment prospects, and opportunities for career advancement [48]. The selection criteria employed by corporations are evident in the assessment of both soft skills and hard skills. The criteria for evaluating soft skills are problem-solving, communication, teamwork, and time management [30, 49]. The criteria for hard skills encompass several areas, like programming, hardware comprehension, information security, and system and application development (Table 4).

Table 4. Sub Criteria

Criteria	Sub Criteria	Definition
Financial Compensation	Salary	Fixed benefits given to employees, routinely every day, month, or year
	Incentive	Additional rewards when employees reach certain targets
Non-Financial Compensation	Working Condition	Something in the employee's work environment that can affect the employee
	Job Prospect	Opportunities for employees to advance in their careers
	Training in Career Development	Programs provided by the company to improve employee competency
Soft Skills	Problem Solving	Ability to identify problems and solve them
	Communication	Ability to convey thoughts orally and in writing
	Team Work	The ability to work with people in a team to achieve the same goals
	Time Management	Ability to manage time and resources in completing tasks

Hard Skills	Programming	Ability to write code in a specific programming language
	Hardware Understanding	Understanding of hardware, how to work, technical specifications, and assembly
	Information Security	The ability to prevent attacks and protect systems, networks and data from attacks
	System and Application Development	Ability to design, implement and test systems, networks and software applications

3-5-3- Making Hierarchy

Based on the acquired criteria, it is possible to construct a hierarchical framework that aids in the development of a matrix for pairwise comparisons. The establishment of the criteria and sub-criteria groupings was informed by the comprehensive review of relevant literature conducted in the preceding chapter (Figure 1).

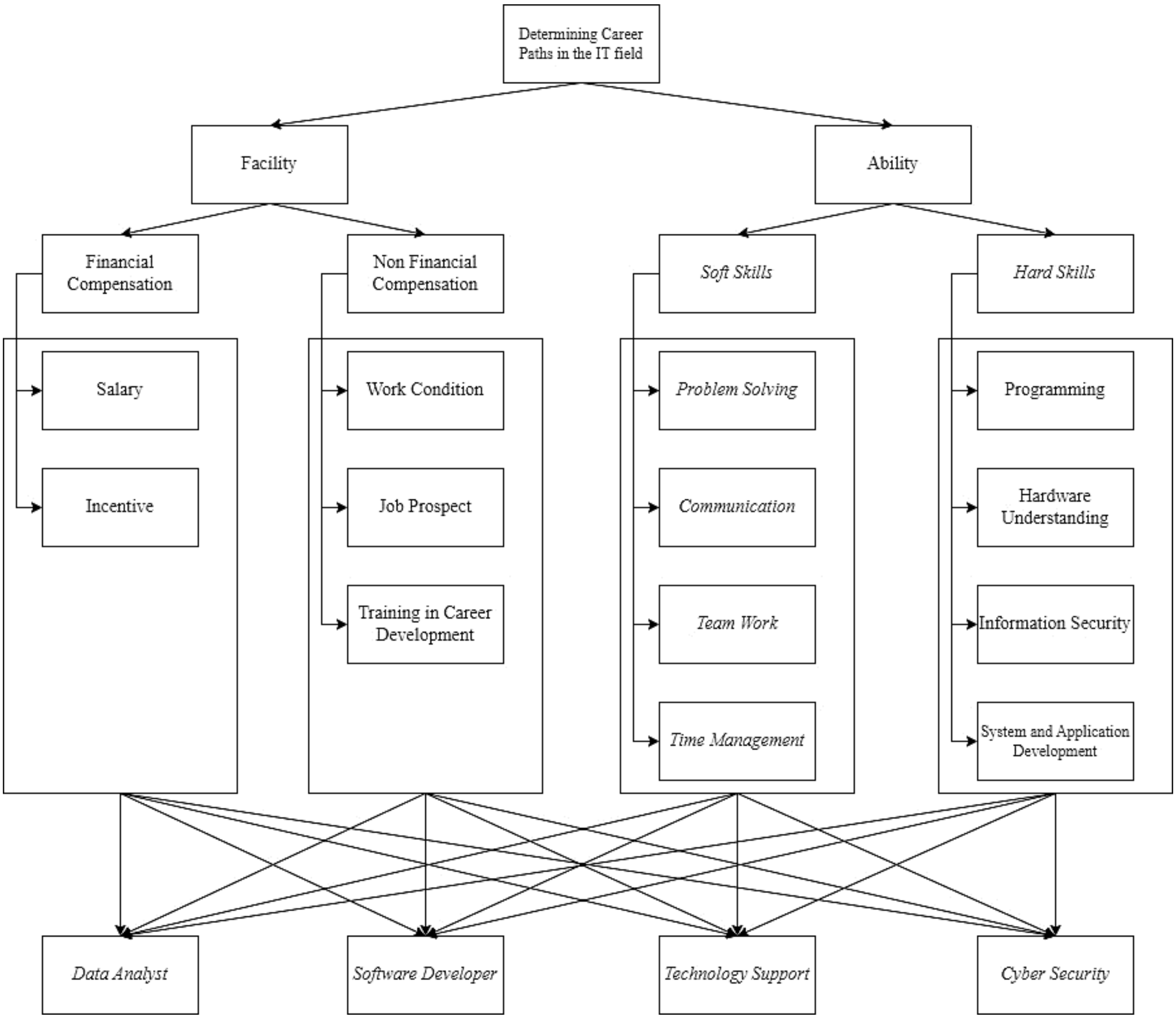

Figure 1. Determining Career Path Hierarchy

3-6- Collecting Data

Once the choice of options and parameters have been established, the next step in the research process is the collecting of data in alignment with the research objectives. This study focuses on a dataset of Informatics Engineering students who have achieved accreditation for excellence at the bachelor level. The objective of this research is to utilize this data in order to determine potential career paths in the field of Informatics Engineering for high-achieving bachelor-level students who are enrolled in recognized Informatics Engineering programs. The collection of data will be facilitated through the distribution of a questionnaire. The questionnaire will comprise inquiries pertaining to the following aspects:

- The educational institution attended by the respondent;
- The field of study pursued by the respondents;
- The degree of education attained by the respondents;
- Interrogations aimed at evaluating the criteria employed by the respondent for the Decision Support Model.

Based on the provided data, it can be inferred that respondents who attended universities offering informatics engineering majors have demonstrated a commendable level of proficiency at the bachelor's degree level. Simultaneously, individuals who do not satisfy these criteria will be excluded from participation in this study. However, they may still serve as samples to evaluate the effectiveness of the procedure in assessing this particular group of respondents.

3-7- Model Building

The next section provides a comprehensive overview of the model-building approach employed in this research.

- The collected data for the questionnaire consists of information from Informatics Engineering students who are accredited and have achieved high levels of academic success at the bachelor's level, as mentioned in the preceding phase.
- The user's text does not contain any information to rewrite. The questionnaire data will be subjected to translation using the Fuzzy Analytic Hierarchy Process (AHP) rules as outlined in the Theory and Method section. The data will be categorized into five distinct groups.
- The criteria will be assessed in order to determine the priority of each criterion in the comparison of alternative choices.
- Once the criteria that are deemed essential for the assessment have been identified, the Decision Alternatives will be evaluated and compared against each criterion individually. Decision alternatives will be more significantly influenced by factors that have a higher priority compared to those with a lower priority.

3-8- Verifying and Validating Model

At this stage, the researcher does the verification and validation of the constructed model. In order to ensure the logical and accurate outcomes of the developed models, the author conducts an examination of them. The approach of the Decision Support Model is subjected to thorough examination during the validation process to guarantee that every action undertaken by the model is in accordance with the established theory. In order to validate the accuracy of the output generated by the Decision Support Model, a subsequent verification of the produced value is conducted. This stage serves to assess the accuracy of the decision support model's construction.

4- Results and Discussion

The decisions of experts are aggregated to provide decisions that encompass the perspectives of all relevant experts, incorporating both interview and questionnaire data. Once the compiled data has been obtained, the subsequent stage involves the process of defuzzification, wherein the data that remains in a fuzzy state is transformed into a crisp, non-fuzzy form. The process of defuzzification is performed in order to derive precise values that can effectively represent fuzzy values, thereby enabling their utilization in the assessment of ranking criteria and sub-criteria. The defuzzification technique employed in this study involves the utilization of the centroid method. The defuzzification findings for the criterion and sub-criteria are presented in Table 5.

Table 5. Pairwise Comparison Matrix for Criteria

	Facility	Ability
Facility	1	1.117
Ability	0.8953	1

Table 5 contains the results of the defuzzification of fuzzy numbers for criteria with sub-criteria facilities and capabilities. Based on Table 5, the facility criteria are more influential than the ability criteria for students when determining their career paths.

Table 6. Pairwise Comparison Matrix for Facility

	Facility	
	Financial Compensation	**Non-Financial Compensation**
Financial Compensation	1	0.6881
Non-Financial Compensation	1.4533	1

Table 6 contains the results of the defuzzification of fuzzy numbers for facility criteria with sub-criteria for financial and non-financial compensation. Based on Table 6, the non-financial compensation sub-criteria is more influential than the financial compensation sub-criteria for students when determining their career paths.

Table 7. Pairwise Comparison Matrix for Ability

Ability		
	Soft Skills	**Hard Skills**
Soft Skills	1	1.7679
Hard Skills	0.5656	1

Table 7 contains fuzzy numbers' defuzzification results for ability criteria with soft skills and hard skills sub-criteria. Based on the table above, the soft skills sub-criteria are more influential than the hard skills sub-criteria for students when determining their career paths.

Table 8. Pairwise Comparison Matrix for Financial Compensation

Financial Compensation		
	Salary	**Incentive**
Salary	1	0.9204
Incentive	1.0865	1

Table 8 contains the results of the defuzzification of fuzzy numbers for financial compensation criteria with salary and incentive sub-criteria. Based on Table 8, the incentive sub-criteria is more influential than the salary sub-criteria for students when determining their career path. This is not done for matrices with a size of 2×2 because comparisons are only made between two criteria so that the matrix is relatively more consistent.

Table 9. Pairwise Comparison Matrix for Non-Financial Compensation

Non-Financial Compensation			
	Working Condition	**Job Prospect**	**Training in Career Development**
Working Condition	1	1.2308	1.2683
Job Prospect	0.8125	1	1.3516
Training in Career Development	0.7885	0.7399	1

Table 9 contains the results of the defuzzification of fuzzy numbers for non-financial compensation criteria, which have sub-criteria of working conditions, job prospects, and training and development. Based on the table above, the working conditions sub-criteria are more influential than the job prospects sub-criteria and the training and development sub-criteria for students when determining their career paths.

After obtaining the defuzzification results, the consistency is checked to ensure consistent comparisons between criteria.

$$CI = \frac{(3.0082247042168566 - 3)}{3 - 1}$$

$$CI = \frac{0.0082247042168566}{2}$$

$$CI = 0.0041$$

$$CR = \frac{0.0041}{0.58}$$

$$CR = 0.0071$$

Because the Consistency Ratio value is 0.0071, lower than 0.1, it can be concluded that the comparison is consistent.

Table 10 contains the results of the defuzzification of fuzzy numbers for soft skills criteria with sub-criteria for problem-solving, communication, teamwork, and time management. Based on the table above, the problem-solving sub-criteria is more influential than the communication, collaboration, and time management sub-criteria for students when determining their career paths.

Table 10. Pairwise Comparison Matrix for Soft Skills

Soft Skills				
	Problem Solving	**Communication**	**Team Work**	**Time Management**
Problem Solving	1	1.5835	1.2745	1.7961
Communication	0.6315	1	0.9944	1.3855
Team Work	0.7846	1.0056	1	1.844
Time Management	0.5568	0.7218	0.5423	1

After obtaining the defuzzification results, the consistency is checked to ensure consistent comparisons between criteria.

$$CI = \frac{(4.014759036942301 - 4)}{4 - 1}$$

$$CI = \frac{0.014759036942301}{3} = 0.0049$$

$$CR = \frac{0.0049}{0.89}$$

$$CR = 0.0055$$

Because the Consistency Ratio value is 0.0055, lower than 0.1, it can be concluded that the comparison is consistent.

Table 11. Pairwise Comparison Matrix for Hard Skills

Hard Skills				
	Programming	**Hardware Understanding**	**Information Security**	**System and Application Development**
Programming	1	1.9812	1.7801	1.2151
Hardware Understanding	0.5047	1	1.0694	0.6981
Information Security	0.5618	0.9351	1	0.8879
System and Application Development	0.823	1.4325	1.1263	1

Table 11 contains the results of the defuzzification of fuzzy numbers for hard skills criteria with sub-criteria for problem-solving, communication, teamwork, and time management. Based on Table 11, the programming sub-criteria is more influential than the sub-criteria for understanding hardware, information security, system development, and applications for students when determining their career paths.

After obtaining the defuzzification results, the consistency is checked to ensure consistent comparisons between criteria.

$$CI = \frac{(4.013214460966296 - 4)}{4 - 1}$$

$$CI = \frac{0.013214460966296}{3}$$

$$CI = 0.0044$$

$$CR = \frac{0.0044}{0.89}$$

$$CR = 0.0049$$

Because the Consistency Ratio value is 0.0049, lower than 0.1, it can be concluded that the comparison is consistent. After obtaining a pairwise comparison matrix with crisp values, the next step is to determine the weight of each criterion to rank each of the existing criteria so that the most influential criteria can be identified in choosing a career path in the IT field.

Table 12. Weights for Criteria

	Facility	**Ability**	**PW**	**Ranking**
Facility	0.5276	0.5276	0.5276	1
Ability	0.4724	0.4724	0.4724	2
		Total	1	

Table 12 contains the normalized weight of the comparison between criteria and the priority weight of the facility and ability criteria. From the priority weight, it can be seen that the facility criteria have a higher weight than the ability criteria.

Table 13. Weights for Facility

Facility	**Financial Compensation**	**Non-Financial Compensation**	**PW**	**Ranking**
Financial Compensation	0.4076	0.4076	0.4076	2
Non-Financial Compensation	0.5924	0.5924	0.5924	1
		Total	1	

Table 13 contains the normalized weight of comparisons between criteria and the priority weight of the criteria for facilities that have sub-criteria for financial compensation and non-financial compensation. From the priority weight, it can be seen that the non-financial compensation sub-criteria has a higher weight than the financial sub-criteria.

Table 14. Weights for Ability

Ability	Soft Skills	Hard Skills	PW	Ranking
Soft Skills	0.6387	0.6387	0.6387	1
Hard Skills	0.3613	0.3613	0.3613	2
		Total	1	

Table 14 contains the normalized weight of the comparison between criteria and the priority weight of the ability criteria with soft skills and hard skills sub-criteria. From the priority weight, it can be seen that the soft skills sub-criteria have a higher weight than the hard skills sub-criteria.

Table 15. Weights for Financial Compensation

Financial Compensation	Salary	Incentive	PW	Ranking
Salary	0.4793	0.4793	0.4793	2
Incentive	0.5207	0.5207	0.5207	1
		Total	1	

Table 15 contains the normalized weight of the comparison between criteria and the priority weight of the financial compensation criteria, which has sub-criteria salary and incentives. From the priority weight, it can be seen that the incentive sub-criteria have a higher weight than the salary sub-criteria.

Table 16. Weights for Non-Financial Compensation

Non-Financial Compensation	Working Condition	Job Prospect	Training in Career Development	PW	Ranking
Working Condition	0.3845	0.4143	0.3504	0.383	1
Job Prospect	0.3124	0.3366	0.3734	0.3408	2
Training in Career Development	0.3032	0.2491	0.2763	0.2762	3
			Total	1	

Table 16 contains the normalized weights for comparison between criteria and priority weights for non-financial compensation criteria, which have sub-criteria for working conditions, job prospects, and training and development. The priority weight shows that the sub-criteria for working conditions is higher than the sub-criteria for job prospects, training, and development.

Table 17. Weights for Soft Skill Compensation

Soft Skills	Problem Solving	Communication	Team Work	Time Management	PW	Ranking
Problem Solving	0.3364	0.3673	0.3344	0.2981	0.334	1
Communication	0.2124	0.232	0.2609	0.2299	0.2338	3
Team Work	0.2639	0.2333	0.2624	0.306	0.2664	2
Time Management	0.1873	0.1674	0.1423	0.166	0.1658	4
				Total	1	

Table 17 contains the normalized weights for comparison between criteria and priority weights for soft skills criteria, which have sub-criteria for problem-solving, communication, teamwork, and time management. The priority weight shows that the problem-solving sub-criteria has a higher weight than the communication, teamwork, and time management sub-criteria.

Table 18. Weights for Hard Skill Compensation

Hard Skills	Programming	Hardware Understanding	Information Security	System and Application Development	PW	Ranking
Programming	0.3461	0.3704	0.3578	0.3197	0.3485	1
Hardware Understanding	0.1747	0.187	0.2149	0.1837	0.1901	4
Information Security	0.1944	0.1748	0.201	0.2336	0.2009	3
System and Application Development	0.2848	0.2678	0.2264	0.2631	0.2605	2
				Total	1	

Table 18 presents the normalized weights for comparing criteria and the priority weights for hard skills criteria, specifically programming sub-criteria, hardware comprehension, information security, and system and application development. The priority weight analysis reveals that the programming sub-criteria holds a greater weight in comparison to the sub-criteria of hardware comprehension, information security, and system and application development.

Once the local weight and level of significance for each criterion and sub-criterion have been determined, the next step involves determining the global weight of the criteria. The calculation of the global weight involves the multiplication of the weight assigned to each subcriterion with the weight assigned to the subcriterion or the criterion directly above it, extending up to the highest hierarchical level.

Table 19. Global Weights

Criteria	Sub Criteria 1	Sub Criteria 2	Global Weight	Ranking
Facility	Financial Compensation	Salary	0.1031	4
		Incentive	0.112	2
	Financial Compensation	Working Condition	0.1197	1
		Job Prospect	0.1065	3
		Training in Career Development	0.0863	6
Ability	*Soft Skills*	Problem Solving	0.1008	5
		Communication	0.0705	8
		Team Work	0.0804	7
		Time Management	0.05	10
	Hard Skills	Programming	0.0595	9
		Hardware Understanding	0.0324	13
		Information Security	0.0343	12
		System and Application Development	0.0445	11

Table 19 presents the outcomes obtained by multiplying the weight of each criterion with the weight of its corresponding subcriterion. The concept of global weight refers to the relative importance or significance of a certain sub-criterion in relation to all other sub-criteria. The weighting of the criteria and sub-criteria is derived from the computational outcomes presented in the preceding table. Based on the obtained global weight, it can be inferred that the primary factors influencing career path determination in this study are working circumstances, which hold the highest rank, followed by incentives and employment prospects, which hold the second and third ranks, respectively.

Upon doing a comprehensive analysis of all option possibilities in relation to the criteria employed in the study, the relative importance of various career paths for each criterion is determined. The determination of career path priority, taking into account all relevant criteria, can be achieved by calculating the product of the weight assigned to each alternative and the global weight assigned to each criterion. Subsequently, the outcomes of each option will be aggregated in order to determine the priority weight of the ultimate alternative decision.

Table 20. Final Results

Criteria	S	I	WC	JP	TCD	PS	C
Weight	0.1031	0.112	0.116	0.1083	0.0883	0.1008	0.0705
Data Analyst	0.3555	0.3297	0.3297	0.267	0.3297	0.4428	0.3297
Software Developer	0.1277	0.2693	0.2693	0.1598	0.2693	0.2513	0.2693
Technology Support	0.2665	0.2208	0.2208	0.0986	0.2208	0.1043	0.2208
Cyber Security	0.2503	0.1802	0.1802	0.4746	0.1802	0.2017	0.1802
Criteria	**TW**	**TM**	**P**	**HU**	**IS**	**SAD**	**Result**
Weight	0.0804	0.05	0.1031	0.112	0.116	0.1083	
Data Analyst	0.2784	0.3083	0.2501	0.1503	0.2072	0.2501	0.3136
Software Developer	0.3593	0.4049	0.4971	0.1223	0.2838	0.4971	0.2747
Technology Support	0.1994	0.1578	0.1393	0.463	0.1468	0.1393	0.1927
Cyber Security	0.163	0.129	0.1135	0.2644	0.3623	0.1135	0.219

Table 20 illustrates the computation of global weights using alternative choice weights. These calculations compare decision alternatives by evaluating all criteria based on their relative weights. Through a comprehensive analysis of the specified criteria, it can be inferred that the optimal career path, as determined by this study, is the Data Analyst profession, which achieves a final weight of 0.3134.

Table 21. Abbreviation for Final Results

Abbreviation	Meaning
S	Salary
I	Incentive
WC	Working Condition
JP	Job Prospect
TCD	Training in Career Development
PS	Problem Solving
C	Communication
TW	Team Work
TM	Time Management
P	Programming
HU	Hardware Understanding
IS	Information Security
SAD	System and Application Development

Table 21 comprises concise explanations of the factors employed in the ultimate table of outcomes for career path determination. Table 21 presents a comprehensive compilation of the abbreviation words utilized within this article. The table provides detailed information regarding these abbreviations.

This study distinguishes itself from prior research by incorporating a broader range of criteria and sub-criteria. Specifically, it considers the facilities offered by the company and the competencies demanded by the company. Furthermore, the dataset employed in this study comprises 18 individuals who have successfully completed an accredited program in Informatics Engineering at the undergraduate level. Additionally, industry experts were consulted to gather insights on the factors influencing career trajectories in the field of Informatics Engineering. This approach ensures the establishment of reliable and consistent comparisons between various criteria and sub-criteria.

5- Conclusions

This research was conducted to determine the career path of Informatics Engineering for highly qualified undergraduate students. The conclusions of this study are:

- The factors needed to build a Decision Support Model consist of 4 main criteria divided into 13 sub-criteria. The first main criterion is Financial Compensation, which has sub-criteria Salary and Incentives. The second criterion is Non-Financial Compensation which has sub-criteria Working Conditions, Job Prospects, and Training and Development Opportunities. The third criterion is Soft Skills which have sub-criteria for Problem-Solving, Communication, Team Work, and Time Management. The fourth criterion, Hard Skills, has sub-criteria Programming, Hardware Knowledge, Information Security, and System and Application Development.
- The Decision Support Model uses the Fuzzy Analytical Hierarchy Process method. This method combines the Analytical Hierarchy Process and Fuzzy Logic methods. The use of Fuzzy Logic in this method is found in the application of fuzzy numbers in comparisons between criteria and sub-criteria. The main objective of this method is to determine the most critical criteria in decision-making and determine the best decision from comparisons between decisions based on the importance of predetermined criteria.
- 3. Based on this research, the criteria with the highest weight include working conditions with a weight of 0.1197, incentives with a weight of 0.112, and job prospects with a weight of 0.1065. So, the criteria that most influence the determination of career paths for Informatics Engineering students with superior qualifications are the working conditions of the job, followed by incentives and job prospects.
- The alternative decision weights produced by this research are Data Analyst weighting 0.3136; Software Developer weighting 0.2747; Technology Support weighting 0.1927; and Cyber Security having a weight of 0.1135. So, the best career path based on the criteria in this study is Data Analyst. This career path includes work in Informatics Engineering, whose job is to process data according to their individual needs.

6- Declarations

6-1- Author Contributions

Conceptualization, E.K.W. and F.L.G.; methodology, E.K.W. and F.L.G.; formal analysis, E.K.W. and F.L.G.; writing—original draft preparation, E.K.W. and F.L.G.; writing—review and editing, E.K.W., F.L.G., and T.M.; supervision, T.M. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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6-5- Institutional Review Board Statement

Not applicable.

6-6- Informed Consent Statement

Not applicable.

6-7- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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