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Development of a Decision Support System for Selecting College Majors Based on an Expert System Using the Forward Chaining Method

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ABSTRACT

Purpose of the study: This study aims to develop a decision support system for selecting higher education majors based on users' personality characteristics using the RIASEC theory. The study also aims to analyze the software quality in terms of correctness, functionality, usability, and maintainability and to examine the suitability of system recommendations with users' preferred majors.

Methodology: This study employed a Research and Development (R&D) approach with the Waterfall software development model. The system was developed using Visual Basic 6.0 and MySQL. RIASEC theory was used as the knowledge base, while decision tree representation and forward chaining were applied for the inference process. Software quality was evaluated through correctness, functionality, usability, and maintainability testing, involving 60 respondents and the Computer System Usability Questionnaire (CSUQ).

Main Findings: The developed system achieved an error/KLOC value of 0 and passed all 34 functionality tests with a 100% success rate. Usability obtained an average score of 72 and was categorized as feasible. All three maintainability aspects instrumentation, consistency, and simplicity meet the criteria. Furthermore, 46 of 60 respondents showed at least one preference matching the system recommendation, resulting in a feasibility rate of 76.67%.

Novelty/Originality of this study: The novelty of this study lies in integrating RIASEC personality theory, decision tree knowledge representation, and forward chaining inference into a decision support system for higher education major selection. The study also combines recommendation development with comprehensive software quality evaluation, providing an integrated approach for educational decision support based on personality characteristics.

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1. INTRODUCTION

Choosing a major in college is a crucial decision in determining the direction of education and developing students' competencies [1], [2]. The choice of major is not only related to the availability of study programs but also requires considering individual characteristics, interests, and tendencies to ensure that the choice aligns with one's potential. Advances in information technology provide opportunities to assist this process through systems capable of processing information and providing recommendations systematically [3].

One form of technology that can be utilized is an expert system-based decision support system, a system that utilizes specific knowledge to help users generate alternative decisions based on given characteristics and conditions [4].

In practice, choosing a college major is not a simple process because prospective students are faced with a wide choice of study programs with different field characteristics [5]. Lack of information and difficulty in recognizing the match between personal characteristics and the field of study can lead prospective students to choose a less suitable major [6], [7]. This problem becomes even more complex when the selection process is based solely on general considerations without a mechanism that can systematically link individual characteristics with recommended majors. Therefore, a system is needed that can assist prospective students in obtaining major recommendations based on knowledge relevant to their characteristics. In this study, Holland's RIASEC personality theory is used as a basis for identifying user characteristic tendencies and linking them to college major choices.

Research on the use of technology to assist in selecting a major has been conducted using various approaches. Decision support systems can be developed using criteria-based decision-making methods, while expert systems can utilize knowledge representation and rules to generate recommendations [8], [9]. The decision tree approach can also be used to represent the relationship between facts, conditions, and decisions, allowing for a structured decision-making process. In the research that forms the basis of this article, the choice of major was constructed using knowledge of Holland's RIASEC personality theory [10]. The knowledge base was structured in the form of production rules in the form of a decision tree, and the inference process was conducted using the forward chaining method, which involves tracing from initial facts or conditions to conclusions.

Although various approaches have been used in the development of a major selection recommendation system, there is still a need to produce a system capable of integrating knowledge of personality characteristics with a rule-based inference mechanism to systematically generate major recommendations. In addition to decision-making ability, software quality is also an important aspect because the recommendation system must be able to function correctly, provide functions that meet user needs, be easy to use, and be maintainable. This study places an expert system as an approach to address this gap by building a knowledge base based on Holland's RIASEC theory and applying forward chaining in its reasoning process. System development also does not stop at application creation, but continues with testing of quality factors such as correctness, functionality, usability, and maintainability [11], [12]. These four factors are explicitly the focus of evaluation in the study.

Developing a decision support system for selecting a major is crucial because decisions regarding a study program can impact the educational process and the direction of prospective students' competency development. A system that provides recommendations based on individual characteristics needs to have a clear reasoning mechanism so that the results provided are not only a choice of major but also can be justified based on the knowledge used. In the developed system, users can also obtain explanations regarding the reasons for statements made and the reasons for conclusions drawn. Furthermore, the system provides information on state universities that offer majors based on the diagnostic results. Thus, the existence of such a system can help users obtain more structured information and recommendations in the process of selecting a college major.

Based on these problems and gaps, this study aims to develop a decision support system for selecting a college major based on an expert system using the forward chaining method. The system was developed by utilizing Holland's RIASEC personality theory as a knowledge base to generate major recommendations according to user characteristics. In addition to developing the system, this study aims to determine the quality of the resulting software based on correctness, functionality, usability, and maintainability factors. The study uses a Research and Development (R&D) approach to produce and test the developed software products [13], [14].

The novelty of this research lies in the integration of Holland's RIASEC personality theory as a knowledge base with decision trees and forward chaining methods in a decision support system for selecting a college major. This integration allows the system to perform a diagnostic process based on user-provided facts to produce structured major recommendations. Another novelty lies in the development of a system that not only generates recommendations but also provides an explanation of the diagnostic process and information about universities that provide the diagnosed majors. The system was then comprehensively evaluated through four software quality factors: correctness, functionality, usability, and maintainability [15], [16]. The results of the study showed that the system met the standards of these four quality factors, while the results of the test of the compatibility of major interests with program outputs indicated that the system was in the "Feasible" category.

2. RESEARCH METHOD

2.1. Research Design and Approach

This research uses a Research and Development (R&D) design that aims to produce and test the feasibility of a software product [17]. The product developed is a Decision Support System (DSS) for College

Major Selection based on an expert system [18]. Software development is carried out using the Waterfall model which includes the stages of requirements analysis , design , coding , and testing . The research approach used is a software development approach with internal and external product quality testing. Internal testing includes quality factors of correctness, functionality, and maintainability , while external testing is carried out on usability factors through end-user assessments.

2.2. Subjects and Objects of Research

The research subjects in the usability testing were users who had the characteristics of potential system users, namely 12th-grade high school students and university students. The number of respondents was 60 people, consisting of 45 12th-grade students from SMA Negeri 2 Wates and 15 university students in Yogyakarta. Respondents were selected using a purposive sampling technique, namely based on the suitability of the respondents' characteristics with potential application users. The object of this research is a software for a Decision Support System for College Major Selection. The system was developed using Visual Basic 6.0 with MySQL as the database. The system's knowledge base is based on John L. Holland's RIASEC personality theory, represented in the form of a decision tree and processed using the forward chaining method.

2.3. Population and Sample

The population used in the user testing was prospective application users, namely 12th-grade high school students and university students who needed information to determine their choice of college major. The research sample consisted of 60 respondents, consisting of 45 12th-grade students from SMA Negeri 2 Wates and 15 university students in Yogyakarta. The sample was determined using purposive sampling based on the suitability of the respondents' characteristics with the application's target users.

2.4. Research Instruments

The research instruments were developed and adapted to the requirements of software quality evaluation. Two main instruments were used, namely observation instruments and questionnaires. Observation instruments were employed to collect data for correctness, functionality, and maintainability testing, while the questionnaire was used to evaluate software usability. The instruments, measurement tools, data collection techniques, and evaluation criteria are summarized in Table 1.

Table 1. Software Quality Testing Instruments and Techniques

Quality factors	Measuring instruments/tools	Data collection technique	Criteria/indicators
Correctness	Code Line Counter and Code Advisor for Visual Basic 6	Code observation/testing	error/KLOC value is compared with the standard used.
Functionality	Application function test case	Functional observation/testing	Primary and supporting functions are running as they should
Usability	The CSUQ questionnaire was developed by JR Lewis and has been adapted	Questionnaire	Ease of use, information, learning, and user satisfaction
Maintainability	Testing instruments for the aspects of instrumentation, consistency, and simplicity	Observation	The system meets the criteria in all three aspects of maintainability.

The usability instrument used in this study was the Computer System Usability Questionnaire (CSUQ) developed by J. R. Lewis. The questionnaire was translated and adapted to the characteristics and requirements of the developed software. It consisted of 19 statements covering ease of use, error handling, information quality, appearance, and user satisfaction. Each statement was assessed using five response options: Strongly Agree,

Agree, Undecided, Disagree, and Strongly Disagree. The distribution of the questionnaire items across the assessed aspects is presented in Table 2.

Table 2. Usability Instrument Grid

Rated aspect	Focus of assessment	Number of grains
Ease of use	Ease and simplicity of system use	1–7
Trust and error handling	User confidence and system response to errors	8–10
Information quality	Clarity, ease of finding, understanding, and using information	11–14
Appearance and satisfaction	Layout, appearance, functionality, and user satisfaction	15–19
Total		19

The instrument grid shows that the 19 questionnaire items were distributed across four assessment aspects. The distribution was designed to capture users' perceptions of system usability, reliability in handling errors, information quality, and overall interface satisfaction. These aspects provided a structured basis for evaluating the usability of the developed software.

2.5. Instrument Validity

Instrument validity was verified by comparing the measurement results using the Code Line Counter with a comparison instrument, the VB6 Pure Code Lines Calculator, to ensure consistency in *the lines of code* (LOC) calculation results. Both instruments produced the same value, namely 5,674 LOC or 5,674 KLOC, so the LOC measurement instrument was declared valid. In usability testing, the instrument used was a CSUQ questionnaire that had been translated and adapted to the application context. Adjustments were made to ensure that each statement could be understood by respondents based on the characteristics of the system being tested.

2.6. Instrument Reliability

The reliability of the Code Line Counter instrument was evaluated by measuring 11 program code files across four measurement stages. The files were divided into four groups, and the LOC obtained from each stage was recorded and subsequently summed to determine the total Lines of Code (LOC). The total measurement was 5,674 LOC, which was consistent with the results obtained using the comparison instrument. This consistency indicates that the Code Line Counter produced stable measurements across the evaluated code files. The results of the LOC measurement reliability test are presented in Table 3.

Table 3. Results of the LOC Measurement Reliability Test

Stage	Calculated files	Results (LOC)
I	3 files	2,698
II	3 files	1,041
III	3 files	1,495
IV	2 files	440
Total	11 files	5,674

The results in Table 3 show that the four measurement stages produced a combined total of 5,674 LOC. The consistency between the Code Line Counter measurements and the comparison instrument confirms the reliability of the measurement process. Therefore, the instrument was considered suitable for determining the number of lines of code in the developed software.

2.7. Data Sources and Data Collection Techniques

The research data sources consist of primary and supporting data. Primary data was obtained from software testing results and user feedback on the application, while supporting data was obtained through literature studies used to build a knowledge base and determine data on majors and universities. Data collection techniques used included literature studies, observation, and questionnaires. Literature studies were used to obtain the theoretical basis for RIASEC, Holland Three-Digit Code data, decision tree concepts , forward chaining , and data on majors and universities. Data on majors and major providers were obtained from 61 state universities in Indonesia and sources referring to O*NET. Observations were conducted on the application to obtain data related to correctness, functionality, and maintainability testing . Meanwhile, a closed-ended questionnaire was used to obtain user assessment data on usability factors . The questionnaire was administered to 60 respondents selected using a purposive sampling technique.

2.8. Research Procedures

The research procedure adopted the Waterfall development model, which provides a sequential approach to system development. The procedure consisted of four main stages: needs analysis, design, coding, and testing. Each stage produced specific outputs that served as inputs for the subsequent stage, ensuring a structured development process. The activities and outputs of each stage are summarized in Table 4..

Table 4. System Development Procedure

Stage	Main activities	External
Needs analysis	Identify system needs, users, department data, RIASEC theory, and *knowledge base needs*	System requirements specifications
Design	System design, database, interface, *knowledge base* , *decision tree* , and *forward chaining rules*	System design
Encoding	Implementation of the design using Visual Basic 6.0 and MySQL	Software products
Testing	*White box testing* , *black box testing* , *alpha* and *beta testing* and software quality analysis	Tested products and quality evaluation results

Testing was conducted after the coding stage to verify the functionality and quality of the developed software. Verification testing included white-box and black-box testing, while product validation involved alpha and beta testing. Software quality evaluation focused on four factors: correctness, functionality, usability, and maintainability. The results of these tests were used to determine whether the developed system met the specified requirements and quality criteria.

2.9. Data Analysis Techniques

Data analysis was performed based on four software quality factors. For the correctness factor, the analysis was performed by calculating the number of errors per kilo lines of code (KLOC). The number of LOC was calculated using Code Line Counter, while the number of errors was analyzed using Code Advisor for Visual Basic 6. A product is considered to meet the correctness factor if the error/KLOC value does not exceed the standard used in the study. In the functionality factor, each application function is tested using test cases. The test results are then compared against the functionality criteria used in the research. The system is declared successful if all primary functions operate as intended and there are no serious supporting function failures that disrupt normal use. For the usability factor, 60 respondents' answers to 19 questionnaire items were scored using a Likert scale of 1–5. The scores obtained were compared to the feasibility categories. Based on the research instrument, these categories were very feasible, feasible, fairly feasible, not feasible, and very not feasible.

Table 5. Usability Feasibility Categories

Score range	Interpretation
$X > 79.8$	Very Worthy
$64.6 < X \leq 79.8$	Worthy
$49.4 < X \leq 64.6$	Quite Decent
$34.2 < X \leq 49.4$	Not feasible
$X \leq 34.2$	Totally Unworthy

For the maintainability factor, analysis is conducted on three aspects: instrumentation, consistency, and simplicity. A product is deemed maintainable if it meets the criteria in all three aspects. Instrumentation is assessed based on the presence of warnings when user errors occur, consistency is based on the uniformity of the system design, and simplicity is based on the system's ease of management, repair, and development.

3. RESULTS AND DISCUSSION

3.1. Decision Support System Development

This research produces a Decision Support System (DSS) to assist prospective students in determining their choice of major in college based on their personality tendencies. The system was developed using the Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (RIASEC) personality theory proposed by John L. Holland. The system's knowledge base is represented in the form of a decision tree, while the conclusion-drawing process uses the forward chaining method. The system is implemented using Visual Basic 6.0 as the programming language and MySQL as the database. The system provides a process for filling in user data, processing personality characteristics, providing recommendations for majors, and supporting information about majors and universities. Thus, the resulting product not only functions as an information storage medium, but also as a system that performs a reasoning process based on the knowledge that has been embedded. The use of RIASEC provides a basis for the system to connect user characteristics with relevant educational field choices, while forward chaining allows the recommendation process to be carried out based on facts provided by the user.

The results of this development indicate that expert systems can be implemented as a technological alternative to assist the educational decision-making process. This approach is relevant because choosing a college major is not always an easy decision for students, especially when students do not yet have sufficient information regarding the suitability of their characteristics with the chosen major. This finding aligns with research by Anwari and Sukirman, who developed a major recommendation system using a decision tree and a Research and Development (R&D) model. This research demonstrated that technology-based systems can be used to assist users in determining major choices. The difference is that this study uses RIASEC theory as the basis for forming a knowledge base and the forward chaining method as the inference mechanism. Thus, the results of this study demonstrate the application of a rule-based expert system that specifically links personality tendencies with recommended college majors.

3.2. *Correctness* Test Results

Correctness testing was conducted to determine the error level in the developed program code. The analysis covered 11 program files containing a total of 5,674 Lines of Code (LOC), equivalent to 5.674 KLOC. The testing identified no code errors, resulting in an error/KLOC value of 0. The LOC measurement was also compared with the results obtained using a comparison instrument, which produced the same total of 5,674 LOC. These results indicate that no coding errors were detected during the testing process that prevented the system from executing its intended processes.

Table 6. Correctness Test Results

Testing Components	Results
Number of program files	11
Total LOC	5,674
Total KLOC	5,674
Number of errors	0
Error/KLOC	0
Status	Passed

The error/KLOC value of 0 indicates that no code errors were detected during the correctness testing process. This result is relevant to the developed decision support system because the accuracy of its recommendations depends on the proper implementation of the programmed rules and inference mechanisms. Errors in the program code could interfere with the execution of the inference process and potentially affect the resulting recommendations. Therefore, the absence of detected code errors provides evidence that the implemented mechanism operated as intended during testing. This finding also supports the technical quality of the software before its use in the user evaluation stage.

3.3. Functionality Test Results

Functionality testing was conducted to verify whether the system functions operated according to the specified requirements. The testing covered 23 primary functions and 11 supporting functions, resulting in a total of 34 tested functions. Each function was evaluated based on whether it produced the expected output and completed the intended process without failure. The results showed that all 34 tested functions operated successfully, with no failed functions identified. Thus, the overall functionality testing achieved a success rate of 100%, as presented in Table 7.

Table 7. Functionality Test Results

Function Types	Number of Functions	Succeed	Fail	Percentage
Primary function	23	23	0	100%
Supporting functions	11	11	0	100%
Total	34	34	0	100%

The results in Table 7 indicate that all primary and supporting functions achieved a 100% success rate. The absence of failed functions demonstrates that the tested system components operated according to their specified requirements. Successful testing of both function types also indicates that the system can perform its main processes and supporting operations as intended. These results provide evidence of the functional completeness of the developed system before proceeding to subsequent software quality evaluations. These results indicate that all primary and supporting functions in the system have worked according to the requirements set out in the development. A 100% success rate indicates that the system is capable of executing a series of processes ranging from user input, data processing, reasoning, and generating recommendations [19]. This finding reinforces the results of the correctness test because the software is not only free from identified code errors but also capable of performing its designed functions. The results of this study are similar to research on the development of a major recommendation system, which places functional testing as a crucial stage to ensure the system can be used as intended. Thus, the functionality aspect is one of the proofs that the developed system has met the functional requirements as a decision support system for major selection.

3.4. Usability Test Results

Usability testing was conducted to evaluate the system from the users' perspective based on their direct interaction with the application. The test involved 60 respondents, consisting of 45 Grade XII students from SMA Negeri 2 Wates and 15 university students in Yogyakarta. The evaluation instrument was adapted from the Computer System Usability Questionnaire (CSUQ), consisting of 19 statements. The collected responses included 231 ratings of Very Appropriate, 537 Appropriate, 275 Undecided, 95 Not Appropriate, and 2 Very Not Appropriate. The overall score was 4,320, with an average value of 72, which falls within the range of $64.6 < X \leq 79.8$ and places the system in the Feasible category. The usability test results are summarized in Table 8.

Table 8. Usability Test Results

Component	Results
Number of respondents	60
High school students	45
Student	15
Number of CSUQ items	19
Total score	4,320
Average value	72
Category	Worthy

The usability results indicate that the developed system achieved the Feasible category based on the established assessment interval. This result suggests that the system can be operated by the target users with an acceptable level of usability. Usability is particularly important for a decision support system because users may not have prior knowledge of expert systems or the forward chaining method. Therefore, system inputs, information, and recommendations need to be presented through an interface that users can understand and operate easily. The finding is consistent with the study by Anwari and Sukirman, which also emphasized the importance of direct user evaluation in assessing the usability of a major recommendation system. Differences between the findings of the two studies may be associated with variations in measurement instruments, respondent characteristics, interface design, and application context. Accordingly, the usability result in this study provides evidence of user acceptance within the context of college major selection.

3.5. Maintainability Test Results

Maintainability testing was conducted to evaluate the ease with which the developed system could be understood, maintained, repaired, and further developed. The evaluation covered three aspects: instrumentation, consistency, and simplicity. Instrumentation refers to the system's ability to provide information or warnings when errors occur, while consistency concerns the uniformity of system components and interfaces. Simplicity refers to the clarity and straightforwardness of the program structure, which can facilitate future maintenance activities. The testing results showed that all three aspects fulfilled the established criteria, as presented in Table 9.

Table 9. Maintainability Test Results

Aspect	Test Results	Status
Instrumentation	Meet the criteria	Passed
Consistency	Meet the criteria	Passed
Simplicity	Meet the criteria	Passed
Overall	3 aspects fulfilled	Passed

The results in Table 9 indicate that the developed system fulfilled the criteria for instrumentation, consistency, and simplicity. These results suggest that the system has characteristics that can support subsequent maintenance and development activities. Maintainability is particularly relevant to a decision support system because its data and decision rules may require updates in response to changes in study programs, universities, and user requirements [20]. A maintainable system can facilitate modifications to the knowledge base and other system components when future changes are required [20], [21]. Therefore, the maintainability results provide evidence not only of the technical condition of the system at the time of evaluation but also of its potential to support future development. This aspect complements the usability and functionality evaluations by considering the sustainability of the system beyond the initial development process.

3.6. Recommendation Results Match with User Choices

In addition to software quality evaluation, this study examined the degree of alignment between respondents' stated major preferences and the recommendations generated by the system. Each of the 60 respondents provided three preferred college majors, which were subsequently compared with the recommendations produced by the developed system. Among the respondents, 46 had at least one preferred major that corresponded with the system recommendations, while 14 respondents had no corresponding choice. The resulting alignment rate was 76.67%. The comparison between system recommendations and respondents' major preferences is presented in

Table 10. Matching System Recommendations with User Choices

Component	Amount	Percentage
Respondents with suitability	46	76.67%
Respondents without conformity	14	23.33%
Total	60	100%

The alignment rate of 76.67% falls within the 61–80% interval and is categorized as Feasible based on the criteria applied in this study. This finding indicates that the system recommendations showed a measurable degree of correspondence with the major preferences reported by the respondents [22]. However, the alignment percentage should not be interpreted as evidence that the system identified the objectively correct major for each respondent [23]. The absence of alignment among 14 respondents suggests that individual major preferences may not always correspond with recommendations derived primarily from RIASEC tendencies [24]. Major selection can also be influenced by factors such as personal interests, academic ability, economic circumstances, family environment, perceived employment opportunities, and individual considerations. Therefore, the developed system is more appropriately positioned as a decision-support tool that provides additional information and recommendations rather than as the sole basis for determining a college major.

When the overall results are analyzed in an integrated manner, the developed system meets the four tested software quality aspects, namely correctness, functionality, usability, and maintainability [25], [26]. Furthermore, the level of agreement between the system's recommendations and user choices reached 76.67%, or is in the "Feasible" category. These results indicate that the RIASEC-based expert system approach, decision trees, and forward chaining can be used to build a decision support system for selecting a college major [27]. Previous research shows that the problem of selecting a college major has also been addressed through other approaches [28]. Anwari and Sukirman used decision trees for major recommendations, while Fauziah and Arifin used Mamdani fuzzy logic for a decision support system for selecting a college major. Other studies have also used profile matching approaches and criteria-based decision-making methods. These differences in approach indicate that selecting a college major is a multidimensional problem that can be solved with various computational methods [29]. The gap filled by this research is the use of an expert system approach that utilizes RIASEC personality characteristics as a knowledge base and forward chaining as an inference mechanism, while simultaneously conducting a comprehensive evaluation of software quality [30]. Thus, this research provides an alternative approach that is more oriented towards knowledge-based reasoning than an approach that is only oriented towards calculating values or classifying data.

The novelty of this research lies in the integration of RIASEC theory, knowledge representation using decision trees, forward chaining inference mechanisms, and software quality evaluation in a single decision support system for college major selection. This novelty does not mean that each method used is new, but rather lies in the application and integration of these approaches in the context of educational decision-making and comprehensive product evaluation. Practically, the system has implications as a tool for students in obtaining alternative major choices and as a support for information services or career guidance in schools. For educational technology developers, the results of this research demonstrate the importance of combining aspects of domain knowledge, recommendation mechanisms, and software quality evaluation in producing educational technology products that can be used in real life. However, this research has several limitations. The system still uses ODBC connections, the knowledge base only uses RIASEC theory, and the university data used is limited to 61 state universities. In addition, the software quality evaluation only covers four factors: correctness, functionality, usability, and maintainability. Therefore, further research can develop a system with a broader coverage of higher education institutions, update study program data, integrate other factors such as academic ability and career preferences, and compare forward chaining with other methods to determine the most appropriate approach in generating major recommendations. Overall, the results of this study indicate that the developed system has met the technical and usability criteria and has the potential to be developed as a technology to support educational decision-making.

4. CONCLUSION

This research produces a Decision Support System (DSS) for selecting a college major based on an expert system using RIASEC theory, decision tree knowledge representation , and the forward chaining method. The system was developed using Visual Basic 6.0 and MySQL to help users obtain major recommendations based on personality characteristics. The test results show that the system meets the correctness aspect with an error/KLOC value of 0, functionality with a success of 34 out of 34 functions or 100%, usability with an average score of 72 in the "Feasible" category, and maintainability that meets all three test aspects, namely instrumentation, consistency, and simplicity . In addition, there are 46 out of 60 respondents or 76.67% who have at least one major choice that matches the system's recommendations, so the level of suitability is in the "Feasible" category. In practice, the developed system can be used as a tool for students to obtain information and alternative recommendations for college majors based on their personality tendencies. This system can also benefit career guidance services in schools by providing additional information that can be used in the consultation process for selecting a major. The implications of this research for the development of educational technology are that the application of expert systems can be an alternative to support educational decision-making by integrating knowledge bases, inference processes, and educational information into a single, directly usable application.

This study has several limitations. The developed system still uses an ODBC connection and the knowledge base used is only based on RIASEC theory. The data on majors and universities available in the system is also limited to 61 state universities, so the scope of recommendations does not represent all available university choices. Furthermore, software quality testing in this study is limited to aspects of correctness, functionality, usability, and maintainability , so it does not cover all other aspects of software quality. The recommendation suitability of 76.67% also indicates that the system's recommendations cannot describe all factors that influence user decisions in choosing a major. Based on these limitations, further research is recommended to develop a system with a broader coverage of universities and study programs and to regularly update the database. The system can also be developed by integrating other factors relevant to major selection, such as academic ability, interests, achievements, career preferences, and job prospects. Furthermore, future research can compare the forward chaining method with expert systems or other decision-making methods to determine the most appropriate approach for generating major recommendations. Quality testing can also be expanded to include other aspects of software quality and a more diverse number and characteristics of users to obtain a more comprehensive system evaluation.

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