Development and Quality Analysis of Decision Support Systems as Software for Scholarship Recommendation in Higher Education

D K Nugroho¹ and H D Hermawan²

¹ Electrical Engineering and Information Technology, Faculty of Engineering, Universitas Gadjah Mada, Indonesia.
² Information and Technology Studies, Faculty of Education, University of Hong Kong, Hong Kong.

E-mail: denikurnianto@mail.ugm.ac.id

Abstract. This study aimed to develop a system that provides scholarship data, recommendations based on students' ability and that ensures that the developed system provides appropriate recommendations according to the students' ability by examining the results of system recommendations on academic, organizational, and student achievement. The research design used a Research and Development (R & D) method and procedures in the development of a scholarship recommendation system using the Extreme Programming (XP) development procedure with four stages: planning, design, coding, and testing. Testing of recommendations was performed by using a guide confusion matrix which tests seven aspects such as accuracy, recall, precision, prevalence, error rate, false positive rate, and specificity. The results of the research showed that: (1) the recommendation system for the selection of scholarships in universities resulted in recommendations using a content-based recommendation method with the weighting of the term frequency-inverse document frequency. (2) Testing the accuracy of the recommendation resulted in a 100% success rate.

1. Introduction

Education is an asset of a nation to produce qualified Human Resources (HR). Quality education enables a nation to advance and excel in global competition. Secretary-General of the Ministry of Education and Culture, Ainun Naim, said that only 30% of students in Indonesia can attain college level [1]. According to Mukhedin & Hasan, the quality of education is a direct consequence of one change and the development of various aspects of life. One of the improvements in the quality of education is by providing scholarships [2].

Problems encountered in several universities in Indonesia is that information about scholarships is not optimal but limited and is also still disseminated in the conventional way, such as brochures, pamphlets, information boards and so on. As a result, many students are not aware of scholarship information. The result of the survey through Google Form distributed in Yogyakarta State University (UNY) stated that of 123 students who filled in the form, 63.4% of them did not know the proper information of scholarships in UNY, and 94.3% stated that there was a need for a good scholarship information system.
in UNY. In the interview with Handono, chairman of the Alumni Association of the Faculty of Engineering (IKA FT) as well as the initiator of the IKA FT scholarship, he said that there is a need for a system that enables students to obtain advice on scholarships that suit their ability so that the given scholarship will be on target.

On the other hand, rapid technological developments, especially in the field of information technology should facilitate all elements involved in the process of receiving scholarships. The integration of ICT in our life changes our relationship with information and knowledge [3]. The development of increasingly evolving technology and content support increasingly make the media paradigm begin to transform from conventional media to digital media that can be accessed using the internet. The use of digital technology using mobile devices is increasing in Indonesia. Also, for the application developed, it is necessary to do testing to prevent the application giving recommendations that are not appropriate. Tests conducted included the level of accuracy of the recommendations produced. To test the recommendations, testing using confusion matrix is used [4].

2. Method

2.1. Development Model

This research used a Research and Development (R&D) method. R&D is a research method used to produce a product and test its effectiveness [5]. The resulting product is a web-based information system. Within the information system, there is a decision support system to provide appropriate scholarship recommendations based on candidates' ability. To obtain optimal results, the system was developed using the Extreme Programming (XP) model. Four framework activities in extreme programming are planning, design, coding and testing [6]. The XP development model is part of lightweight programming methodologies in agile development which is a new form of rapid prototyping in the Rapid Application Development (RAD) method, which is an alternative development methodology in the development of decision support systems [7].

2.2. Development Procedures

Procedure development using software development Extreme Programming (XP) includes the stages of planning, design, coding and testing. Here's an explanation of each stage:

2.2.1. Planning. Planning begins with a "listening" requirement activity. The results will then be entered into the index card to facilitate the planning process.

2.2.2. Design. In the design stage the implementation of the previous stages is carried out as a guide for the development process. This stage represents a more complicated story so that the approach used refers more to the object. Design activity requires class-responsibility-collaborator (CRC) cards to streamline system thinking frameworks in object-oriented contexts.

2.2.3. Coding. Once the story is developed, and the initial design can be used, the writer does not directly perform the programming activity but prepares the unit tests that will test the stories of the increment software. After the unit tests have been completed, the authors’ focus is that the program can meet the unit tests.

2.2.4. Testing. Test is used to know the quality of the software that has been created. In general, testing can be categorized as a "universal testing suite" which includes integration and validation testing. This test can be implemented as part of the software release.
2.3. The Subject, Time and Place of the Study

In the research development research subjects were used to test the classification algorithm (classifier) of the decision support system developed. Testing was performed to minimize the error (error) and ensure that the output produced was expected. The test used a confusion matrix that described the correct and false results of a classification model [8]. The value of the confusion matrix is shown as a percentage (%). Testing was performed using dataset training that was incorporated into the problem-solving algorithm in the decision support system.

The system development was carried out in the laboratory information system of Informatics Engineering Education course and Simpelkes FKKMK Gadjah Mada University, and the implementation of the research ran from May 2017 until June 2017.

3. Implementation

The calculation of recommendation result was performed by considering three factors, including GPA, achievement points, and organizational points. Each factor was assigned a value tag to be matched with the scholarship requirement tags. If the content qualifies, it is weighted with TF-IDF (Term Frequency-Inverse Document Frequency). Table 1 shows Tags of each factor.

| No | Factor   | Attribute | Values                  | Base Attr Point | Cross Attr Point |
|----|----------|-----------|-------------------------|-----------------|------------------|
| 1  | GPA      | Participant | 1.00                   |                 |                  |
|    |          | Finalist   | 1.25                   |                 |                  |
|    |          | Runner-up 3 | 1.75                   |                 |                  |
|    |          | Runner-up 2 | 2.00                   |                 |                  |
|    |          | Runner-up 1 | 2.25                   |                 |                  |
|    |          | 3rd Winner  | 2.50                   |                 |                  |
|    |          | 2nd Winner  | 2.75                   |                 |                  |
|    |          | 1st Winner  | 3.00                   |                 |                  |
|    |          | Bronze Medal | 2.50                 |                 |                  |
|    |          | Silver Medal | 2.75                 |                 |                  |
|    |          | Gold Medal  | 3.00                   |                 |                  |
| 2  | Achievement | Level     | University             | 10              |                  |
|    |          |           | Subdistrict            | 15              |                  |
|    |          |           | Regency/District       | 20              |                  |
|    |          |           | Province               | 25              |                  |
|    |          |           | Regional               | 30              |                  |
|    |          |           | National               | 40              |                  |
|    |          |           | International          | 45              |                  |
|    |          |           | Regional               | 50              |                  |
| 3  | Organization | Position | Member of              | 1.00            |                  |
|    |          |           | Staff                  | 1.25            |                  |
|    |          |           | Head of Department     | 1.75            |                  |
|    |          |           | Head of field          | 2.00            |                  |
The factor is a component that must be met as a requirement of a scholarship; attributes is the completeness of the factors that each has value and points. The process of determining the score is based on the multiplication of the base points by the cross points to obtain the value to be compared. In addition to the tags on the comparable factors, the value of tags for scholarships offered as a requirement must be met. Examples of scholarship tags offered can be seen in Table 2.

Table 2. Scholarship tag values

| No | Scholarship name | GPA | Achievement Points | Organization Points |
|----|------------------|-----|--------------------|---------------------|
| 1  | Scholarship X    | Minimal 3.00 | 10 to 20 | 20 to 80 |
| 2  | Scholarship Y    | Minimal 3.25  | Maximal 3.60 | 40 to 80 | 20 to 50 |
| 3  | Scholarship Z    | Minimal 3.51  | 40 to 100 | 30 to 80 |

Counting tags will become a preference for weighting. The prospective candidate's data will be compared to the tags that have been stored in the database. Table 3 shows an examples of preferences of candidates' data with tag results.

Table 3. The value of self-tagged data of prospective applied candidates

| No | Requirement       | Scholarship X | Scholarship Y | Scholarship Z | DF |
|----|-------------------|---------------|---------------|---------------|----|
| 1  | GPA               | 0             | 0             | 1             | 1  |
| 2  | Achievement Point | 0             | 1             | 1             | 2  |
| 3  | Organization Point| 1             | 0             | 1             | 2  |

Any scholarship that fulfils the requirements will have a score of 1 for the candidate. From the table above, it is shown that the TF of each scholarship, namely: Scholarship X is 1, Scholarship Y is 1, and Scholarship Z is 3. After the TF score of each scholarship is appropriate, the next step is to find the IDF value with the formula following:

$$IDF(t, D) = \log\left(\frac{N}{DF}\right)$$

where:

N = sum of all scholarships

DF = number of requirements met
Table 4 shows the weighted data of each appropriate preference between the values of the tags of the prospective candidate's data with the value of the scholarship requirement tags.

| Requirement       | Weight     |
|-------------------|------------|
| GPA               | \( \log \frac{3}{1} = 0.477 \) |
| Achievement Point | \( \log \frac{3}{2} = 0.176 \) |
| Organization Point| \( \log \frac{3}{2} = 0.176 \) |

Having found the weight of each preference, then the final value of each scholarship is calculated. Table shows the final scholarship scores.

| No | Requirement       | Scholarship X | Scholarship Y | Scholarship Z |
|----|-------------------|---------------|---------------|---------------|
| 1  | GPA               | 0             | 0             | 0.477         |
| 2  | Achievement Point | 0             | 0.176         | 0.176         |
| 3  | Organization Point| 0.176         | 0             | 0.176         |
|    | Total             | 0.176         | 0.176         | 0.829         |

So, we obtain the information of scholarship recommendation from scholarships that are most recommended to candidates in Table 6.

| No | Scholarship’s name | Values |
|----|--------------------|--------|
| 1  | Scholarship Z      | 0.829  |
| 2  | Scholarship X      | 0.176  |
| 3  | Scholarship Y      | 0.176  |

Finally, the order of the most appropriate scholarship recommendations based on the ability of students can be obtained, namely scholarship Z, scholarship X, and scholarship Y.

4. Result

In this research, the accuracy of recommendations and system functionality was investigated. The accuracy of the recommendations was determined with instruments in the confusion matrix which included seven aspects, including accuracy, error rate, recall, false positive rate, specificity, precision and prevalence. The test used a test case arranged at the design stage. The test case was used to facilitate the testing. The test cases included the requirements of scholarships and student data. There were additional data requirements raised on the recommendation, i.e. candidates have to meet all aspects of the GPA, achievement points and organizational points, so that the recommendations that appear are scholarships with a score of 3. Table 7 shows the requirements of scholarships in the test case. The experiment was conducted six times with different candidate criteria.
### Table 7. Test case of scholarship requirements

| No | Scholarship’s name                | GPA  | Achievement Point | Organization Point |
|----|----------------------------------|------|-------------------|--------------------|
| 1  | Bidikmisi                         | 3.00 | 10 – 20           | 20 – 80            |
| 2  | PPA                               | 3.25 | 40 – 80           | 20 – 50            |
| 3  | BBPPPA                            | 3.51 | 40 - 100          | 30 - 80            |
| 4  | ADIK Scholarship                  | 3.00-3.51 | 0              | 10                 |
| 5  | ADIK Papua Scholarship            | 2.75-3.25 | 0            | 0                  |
| 6  | BU DIKTI                          | 3.51 | 150               | 80                 |
| 7  | Dikpora Government Scholarship    | 3.00–3.75 | 20 - 100     | 20 – 80            |
| 8  | Dikpora Government Scholarship Aid| 3.00–3.75 | 20 - 100     | 20 – 80            |
| 9  | Indonesian Bank Scholarship       | 3.60 | 10 - 100          | 10 – 300           |
| 10 | Supersemar Scholarship            | 3.25–3.50 | 50            | 30 – 500           |
| 11 | BU Supersemar                     | 3.51 | 100 - 800         | 60 – 800           |
| 12 | Toyota and Astra Foundation Scholarship | 3.25 | 40 - 1000 | 40 – 950          |
| 13 | Salim Scholarship                 | 3.00–3.60 | 30 - 800     | 30 – 550           |
| 14 | Orbit Foundation Scholarship      | 3.30–3.75 | 10            | 10                 |
| 15 | POMNAST Medal Scholarship         | 2.75 | 50                | 0                  |

The experiment was conducted 6 times with different applicant candidate criteria. Here is the experimental data:

1) First trial
   - GPA = 2.75, achievement point = 0, organizational point = 0
   - Scholarship is displayed: ADIK Papua
   - The corresponding scholarships are displayed (TP): 1
   - Unsuitable scholarships are displayed (FP): 0
   - The corresponding scholarships are not shown (TN): 0
   - Accuracy: ((1+0)/1) * 100% = 100%
   - Error rate: ((0+0)/1) * 100% = 0%
   - Recall: ((1/1)+0) * 100% = 100%
   - False Positive Rate: (0/(0+0)) * 100% = 0%
   - Specificity: (0/(0+0)) * 100% = 0%
   - Precision: (1/(1+0)) * 100% = 100%
   - Prevalence: 1/1 = 1

2) Second Trial
   - GPA = 3.51, achievement point = 0, organization point = 0
   - Scholarship is displayed: ADIK
   - The corresponding scholarships are displayed (TP): 1
   - Unsuitable scholarships are displayed (FP): 0
   - The corresponding scholarships are not shown (TN): 0
   - Accuracy: ((1+0)/1) * 100% = 100%
   - Error rate: ((0+0)/1) * 100% = 0%
   - Recall: ((1/1)+0) * 100% = 100%
   - False Positive Rate: (0/(0+0)) * 100% = 0%
   - Specificity: (0/(0+0)) * 100% = 0%
   - Precision: (1/(1+0)) * 100% = 100%
   - Prevalence: 1/1 = 1
3) **3rd Trial**

- GPA = 3.25, achievement point = 69, organization point = 0
- Scholarships are displayed: ADIK Papua and POMNAS Medal Scholarship
- The corresponding scholarships are displayed (TP): 2
- Unsuitable scholarships are displayed (FP): 0
- The corresponding scholarships are not shown (TN): 0

**Accuracy:** \(\frac{(2+0)}{2} \times 100\% = 100\%\)

**Error rate:** \(\frac{(0+0)}{2} \times 100\% = 0\%\)

**Recall:** \(\frac{(2/2)+0}{} \times 100\% = 100\%\)

**False Positive Rate:** \(\frac{0}{(0+0)} \times 100\% = 0\%\)

**Specificity:** \(\frac{0}{(0+0)} \times 100\% = 0\%\)

**Precision:** \(\frac{2/(2+0)}{} \times 100\% = 100\%\)

**Prevalence:** \(\frac{2/2}{2} = 1\)

4) **4th Trial**

- Scholarships are displayed: ADIK Papua and POMNAS Medal Scholarship
- The corresponding scholarships are displayed (TP): 2
- Unsuitable scholarships are displayed (FP): 0
- The corresponding scholarships are not shown (TN): 0

**Accuracy:** \(\frac{(2+0)}{2} \times 100\% = 100\%\)

**Error rate:** \(\frac{(0+0)}{2} \times 100\% = 0\%\)

**Recall:** \(\frac{(2/2)+0}{} \times 100\% = 100\%\)

**False Positive Rate:** \(\frac{0}{(0+0)} \times 100\% = 0\%\)

**Specificity:** \(\frac{0}{(0+0)} \times 100\% = 0\%\)

**Precision:** \(\frac{2/(2+0)}{} \times 100\% = 100\%\)

**Prevalence:** \(\frac{2/2}{2} = 1\)

5) **5th Trial**

- GPA = 2.75, Achievement point = 10, organization point = 50
- Scholarship is displayed: ADIK Papua
- The corresponding scholarships are displayed (TP): 1
- Unsuitable scholarships are displayed (FP): 0
- The corresponding scholarships are not shown (TN): 0

**Accuracy:** \(\frac{(1+0)}{1} \times 100\% = 100\%\)

**Error rate:** \(\frac{(0+0)}{1} \times 100\% = 0\%\)

**Recall:** \(\frac{(1/1)+0}{} \times 100\% = 100\%\)

**False Positive Rate:** \(\frac{0}{(0+0)} \times 100\% = 0\%\)

**Specificity:** \(\frac{0}{(0+0)} \times 100\% = 0\%\)

**Precision:** \(\frac{1/(1+0)}{} \times 100\% = 100\%\)

**Prevalence:** \(\frac{1/1}{1} = 1\)

6) **6th Trial**

- GPA = 3.52, achievement point = 50, organizational point = 50
- Scholarships are displayed: PPA, BBPPPA, Dikpora Government Scholarship, Dikpora Government Scholarship Aid, Salim Scholarship, Orbit Foundation Scholarship, POMNAS Medal Scholarship
- The corresponding scholarships are displayed (TP): 7
- Unsuitable scholarships are displayed (FP): 0
- The corresponding scholarships are not shown (TN): 0

**Accuracy:** \(\frac{(7+0)}{7} \times 100\% = 100\%\)

**Error rate:** \(\frac{(0+0)}{7} \times 100\% = 0\%\)

**Recall:** \(\frac{(7/7)+0}{} \times 100\% = 100\%\)
False Positive Rate: \( \frac{0}{(0+0)} \times 100\% = 0\% \)
Specificity: \( \frac{0}{(0+0)} \times 100\% = 0\% \)
Precision: \( \frac{7}{(7+0)} \times 100\% = 100\% \)
Prevalence: \( \frac{7}{7} = 1 \)

Based on the results of the conducted tests, the percentage of application capability level in regard to the results of recommendations was obtained as shown in Tables 8 to 14.

**Table 8. Accuracy test results**

| Testing | Relevant data retrieved | Irrelevant data not retrieved | Data retrieved | Accuracy |
|---------|-------------------------|-------------------------------|----------------|----------|
| 1       | 1                       | 0                             | 1              | 100%     |
| 2       | 1                       | 0                             | 1              | 100%     |
| 3       | 2                       | 0                             | 2              | 100%     |
| 4       | 2                       | 0                             | 2              | 100%     |
| 5       | 1                       | 0                             | 1              | 100%     |
| 6       | 7                       | 0                             | 7              | 100%     |

*Average Test 100%*

4.1. **Accuracy**

Based on the calculation of the percentage of accuracy level, the average percentage of the number of data records classified correctly by a classifier was 100% (Table 8). It can be concluded that the system can provide the relevant data in full when viewed from the entire data displayed.

4.2. **Error rate**

Table 9 shows the calculation result of error rate that got the average of the percentage of total classifier makes prediction error 0%. The conclusion is that the system can prevent the emergence of irrelevant data from the entire data displayed.

**Table 9. Error rate test results**

| Testing | Irrelevant data retrieved | Irrelevant data not retrieved | Data retrieved | Error rate |
|---------|---------------------------|-----------------------------|----------------|------------|
| 1       | 0                         | 0                           | 1              | 0%         |
| 2       | 0                         | 0                           | 1              | 0%         |
| 3       | 0                         | 0                           | 2              | 0%         |
| 4       | 0                         | 0                           | 2              | 0%         |
| 5       | 0                         | 0                           | 1              | 0%         |
| 6       | 0                         | 0                           | 7              | 0%         |

*Average Test 0%*

4.3. **Recall**

Regarding the calculation of recall rate percentage that is shown in Table 10, the average percentage of the proportion of the actual positive cases is predicted to be 100% correct. In conclusion, the system is capable of providing data to the user appropriately. No information was lost so that the user can receive all the information appropriately.
### Table 10. Recall test results

| Testing | Relevant data retrieved | Irrelevant data not retrieved | Data retrieved | Recall |
|---------|-------------------------|-------------------------------|----------------|--------|
| 1       | 1                       | 0                             | 1              | 100%   |
| 2       | 1                       | 0                             | 1              | 100%   |
| 3       | 2                       | 0                             | 2              | 100%   |
| 4       | 2                       | 0                             | 2              | 100%   |
| 5       | 1                       | 0                             | 1              | 100%   |
| 6       | 7                       | 0                             | 7              | 100%   |
| Average Test |                   |                               |                | 100%   |

#### 4.4. False positive rate
The calculation of the percentage of the false positive rate shown in Table 11 and which obtained the average percentage of positive data is 0%. It can be concluded that the system can prevent irrelevant data being displayed in the entire data.

### Table 11. False positive rate test results

| Testing | Irrelevant data retrieved | Irrelevant data not retrieved | Data retrieved | False positive rate |
|---------|---------------------------|-------------------------------|----------------|---------------------|
| 1       | 0                         | 0                             | 1              | 0%                  |
| 2       | 0                         | 0                             | 1              | 0%                  |
| 3       | 0                         | 0                             | 2              | 0%                  |
| 4       | 0                         | 0                             | 2              | 0%                  |
| 5       | 0                         | 0                             | 1              | 0%                  |
| 6       | 0                         | 0                             | 7              | 0%                  |
| Average Test |                   |                               |                | 0%                  |

#### 4.5. Specificity
Based on the calculation, the average percentage of negative data predicted as negative data is 0%. This is shown in Table 12. In conclusion, the system can prevent the absence of relevant data from the entire data.

### Table 12. Specificity test results

| Testing | Relevant data not retrieved | Irrelevant data retrieved | Data retrieved | Specificity |
|---------|-----------------------------|---------------------------|----------------|-------------|
| 1       | 0                           | 0                         | 1              | 0%          |
| 2       | 0                           | 0                         | 1              | 0%          |
| 3       | 0                           | 0                         | 2              | 0%          |
| 4       | 0                           | 0                         | 2              | 0%          |
| 5       | 0                           | 0                         | 1              | 0%          |
| 6       | 0                           | 0                         | 7              | 0%          |
| Average Test |                   |                           |                | 0%          |
4.6. Prevalence
Based on the calculation of the percentage prevalence rate of the scholarship recommendation system, the average percentage proportion of the number of positive predicted cases is 100% and it shows in the table 13. It can be concluded that the system is capable of displaying relevant data in the overall data.

| Testing | Relevant data retrieved | Irrelevant data retrieved | Data retrieved | Prevalence |
|---------|-------------------------|---------------------------|----------------|------------|
| 1       | 1                       | 0                         | 1              | 100%       |
| 2       | 1                       | 0                         | 1              | 100%       |
| 3       | 2                       | 0                         | 2              | 100%       |
| 4       | 2                       | 0                         | 2              | 100%       |
| 5       | 1                       | 0                         | 1              | 100%       |
| 6       | 7                       | 0                         | 7              | 100%       |
|         |                         |                           |                | Average Test | 100%       |

5. Conclusion
Based on the results of research and discussion that has been presented, it can be concluded that the recommendation system of scholarship election developed in this study has tested the level of accuracy of the recommendations. The accuracy, recall, precision, and prevalence levels of this recommendation system are 100% which means the recommendation system is included in the Excellent Classification category and is capable of processing data without error to be presented to the user. The rate error rate, false positive rate, and specificity with 0% indicates that the system can prevent data errors very well. In addition, this system also still has limitations such as not yet being integrated with other systems, such as Siakad (Academic Information System) and also the absence of an online list feature, so the process of collecting files is still manual.

6. References
[1] I Ningtyas 2014 Juni 7 Hanya 30 Persen Pelajar Bisa Kuliah (Tempo: Indonesia)
[2] A Kusumam, Mukhidin & B Hasan 2016 Pengembangan Bahan Ajar Mata Pelajaran Dasar dan Pengakuan Listrik untuk Sekolah Menengah Kejuruan (Jurnal Pendidikan Teknologi dan Kejuruan) vol 23 p28-39
[3] H Fitriyadi 2013 Integrasi Teknologi Informasi Komunikasi Dalam Pendidikan: Potensi Manfaat, Masyarakat Berbasis Pengetahuan, Pendidikan Nilai, Strategi Implementasi dan Pengembangan Profesional (Jurnal Pendidikan Teknologi dan Kejuruan) vol21(3) p269-284
[4] A Indriani 2014 Klasifikasi Data Forum dengan menggunakan Metode Naïve Bayes Classifier (Seminar Nasional Aplikasi Teknologi Informasi (SNATI)) p5 (Yogyakarta: Universitas Islam Indonesia)
[5] Sudaryono 2015 Metode Riset di Bidang TI Panduan Praktis, Teori dan Contoh Kasus (Yogyakarta: Penerbit Andi)
[6] R S Pressman & B R Maxim 2014 Software Engineering: A Practitioner's Approach 8th ed (New York: McGraw-Hill Education)
[7] E Turban, J E Aronson & T-P Liang 2005. *Decision Support System and Intelligent System* 7th ed (New Delhi: Prentice-Hall of India Private Limited)

[8] A Musthafa, H Suyono & M Sarosa 2015 *Perbandingan Kinerja Algoritma C.45 dan AHP-TOPSIS Sebagai Pendukung Keputusan Proses Seleksi Penerima Beasiswa* (Jurnal EECCIS) vol 9(2) p109-114