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Computational thinking-based informatics material recommendation system for vocational school students with the content-based filtering method

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Abstract: The system is built by displaying the results of material recommendations and the results of the accuracy test of student material recommendation scores based on students' computational thinking. The processes carried out are tokenization, stopword removal, stemming, and weighting. The results of the extraction were then compared using the cosine similarity approach. The greater the cosine-similarity value produced, the more similar the two data are, so that the material recommendations will be based on the smallest cosine-similarity value between the extraction of student recommendation data. The system built has met the needs of functionality that answer the results of the problem analysis determined at the beginning of the research. This is by the results of system functionality testing carried out using black box testing. The system has been by the plan.

Keywords: *Computational thinking, Content-based filtering, Informatics materials. Recommendation system.*

1. Introduction

The development of the Industrial Revolution 4.0 currently has an impact on the rapid development of science and technology. All areas of life are directed towards the use of digital technology. One of them is in the field of education, entering the industrial revolution in the world of education is required to construct learning that involves technology. The education revolution 4.0 is a term used by education experts to describe how to implement technology into learning.

One of the improvement thinking skills that students must have in facing the 4.0 education era is Computational Thinking. According to [1], Computational thinking is defined as the thought process involved in formulating a problem, and its solution is represented in a form that can be done effectively in processing information. Thus, computational thinking must be embedded in the education system as a substantial learning goal to prepare students with future competencies. According to [2], computational thinking is very important because, with the application of computational thinking, students are trained to think gradually, systematically and creatively using computers and the internet.

Computational thinking is a method to train how to think in solving problems using several techniques in the fields of computer science, science, and informatics. According to [3], the use of computational thinking in learning can increase students' desire to learn thereby increasing students' learning achievement. The use of computational thinking in learning can increase students' desire to learn thereby increasing students' learning achievement. This is shown from the results of research on the application of computational thinking in structural programming teaching materials that divide the learning group into two, namely, the study group that applies computational thinking in learning, and the group that does not use computational thinking. The result is that the group that uses computational thinking in learning can solve programming problems with significant goals compared to the group that does not.

The implementation of the Independent Curriculum is a curriculum that optimizes students to

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explore concepts and strengthen competencies and aims to restore education in Indonesia after the COVID-19 pandemic. Vocational High Schools (SMK) in Indonesia have implemented an independent curriculum since 021, and this has caused several impacts that have become problems in educational activities at vocational schools [4]. Differentiated learning is a learning strategy that emphasizes the accommodation of individual differences of students in the learning process. In the context of the independent curriculum, differentiated learning is one of the effective strategies to accommodate individual student differences [5]. So far, in vocational schools, especially differential learning based on computational thinking, there has never been a system design that applies the concept of algorithms as a benchmark for providing material to students based on web applications so that students can be classified based on the ability to absorb material at each level of computational thinking.

Faisal, the Principal of SMK Negeri 3 Lhokseumawe City as well as the Chairman of MGMP ICT stated that the current student competency development activities have not focused on the development of Computational Thinking which focuses on student analysis. The activity only focuses on learning activities. This is evidenced by the fact in the field that the process of learning activities has not been maximized in the use of media and technology in learning. In addition, from the results of the study [6] stated that especially in informatics materials, a number of weaknesses were still found, such as the importance of improving students' cognition to solve programming algorithm problems with a background in information technology. Therefore, it is necessary to make efforts to find out students' Computational Thinking abilities so that learning will be better in the future [7].

Furthermore, according to the chairman of MGMP ICT SMK, the assessment of student evaluation in the learning process is usually carried out with student learning evaluation activities which are routinely carried out at the end of each teaching semester with the aim of obtaining information related to the good and bad learning activities that have been implemented in the classroom [8]. Student learning evaluation should be used as a reflection material for teachers in developing and implementing the Computational Thinking component [9].

In the study [10], the results of the study showed that P5 activities based on several indicators as the application of differentiated learning in the independent curriculum starting from the planning, implementation, management, assessment, evaluation and follow-up plans for the next activities ran very well and structured. Differentiated learning has been well implemented through the implementation of P5 activities and the use of learning methods that adjust to students' interests. P5 activities carried out as a form of differentiated learning in the independent curriculum have a positive impact on the development of students.

In the research [11], a research study was carried out on the selection of courses in accordance with the interests and understanding of courses that have certain subjectivity and needs. In many cases, students have little knowledge about the purpose of a course so they tend to guess or follow the flow of lectures. In the study, an analysis was carried out using the Content Based Filtering algorithm to recommend courses that were in accordance with the basic knowledge of students and the results of the experiment proved that the proposed algorithm was accurate and effective. However, the study did not use the analysis of the level of computational thinking where students' abilities could be measured effectively.

In addition, research conducted by [12] found an increase in the value of using English teaching resources by using a collaborative filtering algorithm. The intelligent system model built in the study provides personalized learning content recommendations according to the student's learning background so that the intelligent system built with the algorithm has high-quality recommendations to determine students' abilities in learning needs. However, in this study, there is no recommendation for students to specialize in science and mathematics with analytical computational thinking designed in a system that will be built in this study so that students, especially in vocational schools specializing in informatics, can master aspects of students' fields of interest well.

In this study, a web-based system was designed with the implementation of Python programming language and a Content-Based Filtering algorithm to analyze material in accordance with the level of students' computational thinking skills through learning evaluation. The advantage of this algorithm is that this algorithm has been widely proven to test recommendation systems that can optimize the model

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built. This algorithm has also proven that the recommended system can improve the quality of resources and provide more suitable recommendations for the recommendation platform. This is very useful for improving the quality of student learning [13].

2. Method

The method used in this study is using two research methods, namely the data collection method and the system development method. In the data collection method, several stages of data collection are carried out such as observation, interviews, questionnaires, document studies, case studies, and secondary data collection. Meanwhile, in the system development method, the researcher conducts the stage of system needs analysis (Software and Hardware) and system testing analysis using the waterfall method. The following explains the system design flowchart used in this study has been illustrated in Figure 1:

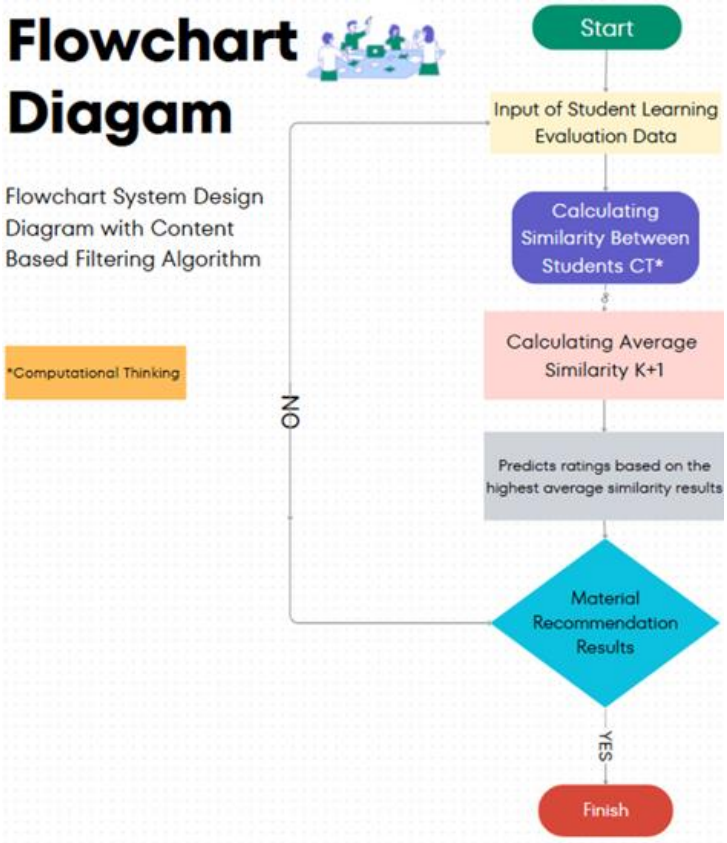

Figure 2.
Flowchart system with content-based filtering algorithm.

Based on the system design flowchart above, in the initial stage, data input is based on student learning evaluations and then processed with a content-based filtering algorithm where the input data will be calculated similarly based on the level of students' computational thinking. Then, the algorithm calculation will calculate the average similarity K+1, which is the similarity between students, and then predict the rating based on the highest average similarity results to get the results of recommendations for informatics materials that are by the level of computational thinking that students have.

2.1. Content Based Filtering Algorithm

Content-based filtering is one of the popular methods in the data recommendation and analysis system, this algorithm focuses on the characteristics or content of the item to be recommended or [14].

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To provide relevant recommendations, content-based filtering considers the interests and preferences of each user. This method uses the features and attributes of items to meet the user's desires so that the recommendations given will be better tailored to the user's needs and interests [15]. The following explanations have been illustrated in Figure 2.

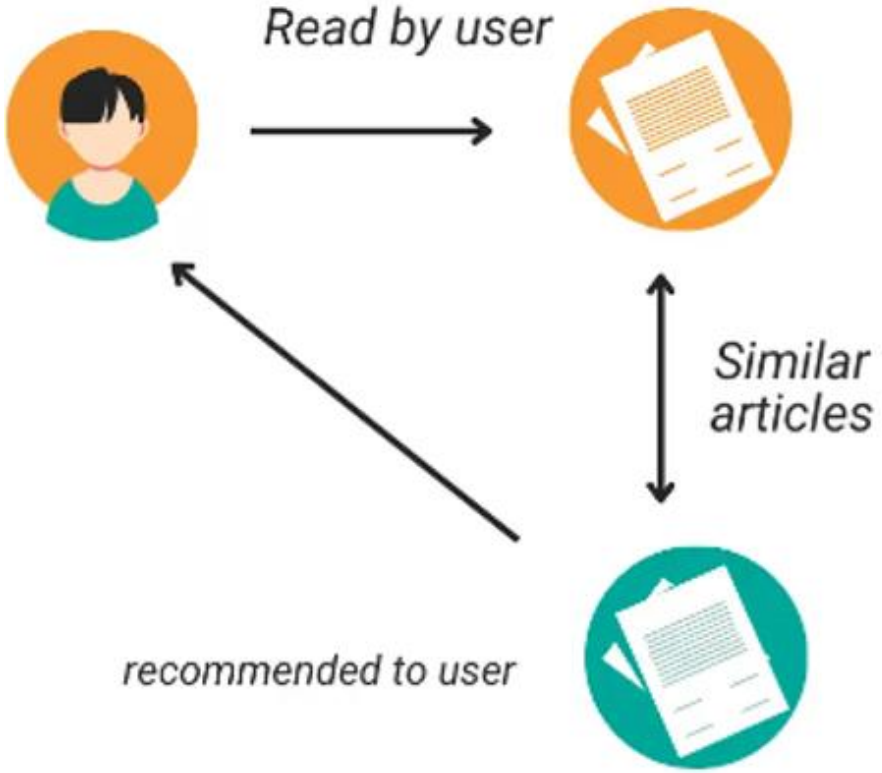

Figure 2.
Content-based filtering.
Source: https://dqlab.id/content-based-filtering-dalam-algoritma-data-science.

Based on the figure above, three types of content-based filtering are used in various contexts and applications, namely text-based content-based filtering, image-based content-based filtering, and video-based content-based filtering. It can be concluded that content-based filtering is used in the recommendation system to recommend content to users based on their characteristics or content similarities.
In building a recommendation system using the content-based filtering algorithm, it can be done through the following stages:

2.1.1. Profile Item Formation

Profile Items are formed from the data that has been collected, namely based on the level of Computational Thinking (CT) of students and are hereinafter referred to as student profiles that are the content of the research [16].

2.1.2. Preprocessing

Preprocessing is a stage of the process of changing the form of unstructured data into structured data so that it is suitable for processing to the next stage. Several stages of preprocessing are carried out, namely case folding, tokenization, elimination, filtering, and stemming [17].

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2.1.3. Cosine Similarity

Cosine similarity is a calculation that is often used to calculate similarities between items. In general, the similarity function accepts two object profiles in the form of real numbers (0 and 1) and returns the similarity value between the two objects in the form of real numbers. The cosine similarity function between item A and item B is shown as follows [18].

$$sim(A,B) = \frac{n(A \cap B)}{\sqrt{n(A)n(B)}} \quad (1)$$

Information:

sim(A, B): similarity values of items A and B

n(A): many features of item A content

n(B): many features of item B content

n(A∩B): the number of content features contained in item A and also found in item B

If the result of the calculation obtains that the two objects have a similarity value of 1, then the two objects are said to be identical and vice versa. The greater the result of the similarity function, the more similar the two objects are considered, and vice versa.

2.1.4. Top-N Recommendation

The user selects from the items generated from the similarity calculation. Only N items with the highest similarity value are selected, and it is considered that the user is likely to choose similar items with a higher similarity value.

2.1.5. Confusion Matrix

Confusion matrix is one of the methods that can be used to measure the performance of a system. The confusion matrix contains information that compares the classification results carried out by the system with the classification results that should be, precise and accurately formulated with equations [19].

Table 1.

		True value	
		True	**False**
Prediction value	True	True positive (TP)	False positive (FP)
	False	False negative (FN)	True negative (TN)

In this study, a Content-Based Filtering algorithm is used which focuses on student objects based on the ability of students who have a level of computational thinking to then be used as a rating matrix in the calculation of methods in the system.

2.2. Computational Thinking in Informatics Materials

Computational Thinking learning carried out with informatics learning can be done by preparing the necessary steps according to the instructions on each algorithm. There are many variations in patterns in case resolution. One example is learning to make a simple mathematics-based algebra program by arranging steps according to instructions [20]. The stages of completing the instruction in the application of computational thinking are as follows:

1. Model functions in algebra through programs (compare them with functions in programs).
2. Write down an algorithm (or the exact sequence of steps) about how to do matrix multiplication or how to solve a quadratic equation.
3. Use decomposition to solve word problems.
4. Generalization (as an algebraic representation) by identifying patterns.

Some things will be solved faster by humans and some will be solved faster with computers, we as humans are the ones who decide. In practice, there is a set of abilities that are part of computational thinking. Google for Education discusses how a computational thinking approach should be. Google for Education has four basic steps consisting of decomposition, pattern recognition, abstraction, and

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algorithm design (Kidd, Lonnie R, & Morris, Jr., 2017). Here is the definition of the four basic steps (BBC Bitesize, n.d.)

3. Results and Discussion

The method used in this study is using two research methods, namely the data collection method and the system development method. In the data collection method, several stages include observation, interviews, questionnaires, document studies, case studies and secondary data collection. Meanwhile, in the system development method, the researcher conducts the stage of system needs analysis (Software and Hardware) and system testing analysis using the waterfall method. The following explains the system design flowchart used in this study:

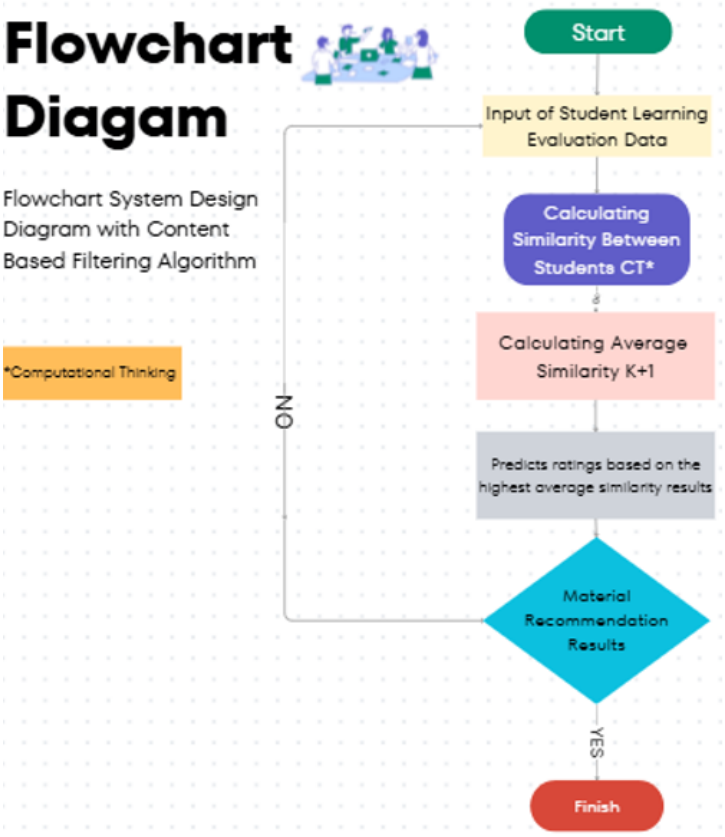

Figure 3.
System design flowchart with content-based filtering algorithm.

Based on the system design flowchart above, in the initial stage, data input is based on student learning evaluations and then processed with a content-based filtering algorithm. The input data will be calculated similarly based on the students' computational thinking level. Then, the algorithm calculation will be calculated as an average similarity K+1, which is the similarity between students, then the rating based on the highest average similarity results to get the results of recommendations for informatics materials that are by the level of computational thinking that students have.

3.1. Overview

The development of the recommendation system was made using data from the learning evaluation results of Lhokseumawe City Vocational School students which had been grouped based on the level of students' Computational Thinking and calculated the rule base using the Tsukamoto Fuzzy Inference method. In data grouping, data is generated in the form of weighting that will be input into the system

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to be built, namely using a GUI-based system with python. The results of data processing taken from the database are designed to calculate recommendations for informatics materials by processing descriptions on each content. Then data processing is carried out until it produces similarity values between materials. The system schematic is depicted in Figure 4. system scheme and Figure 5. Content-Base Filtering Algorithm Scheme.

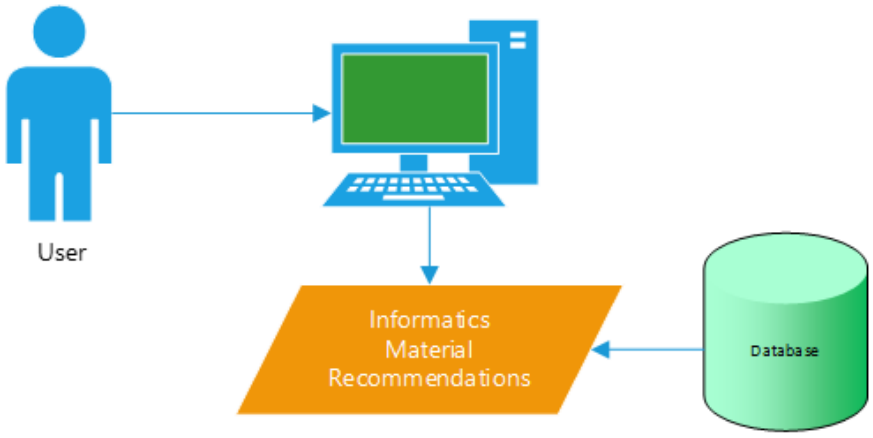

Figure 1.
System scheme.

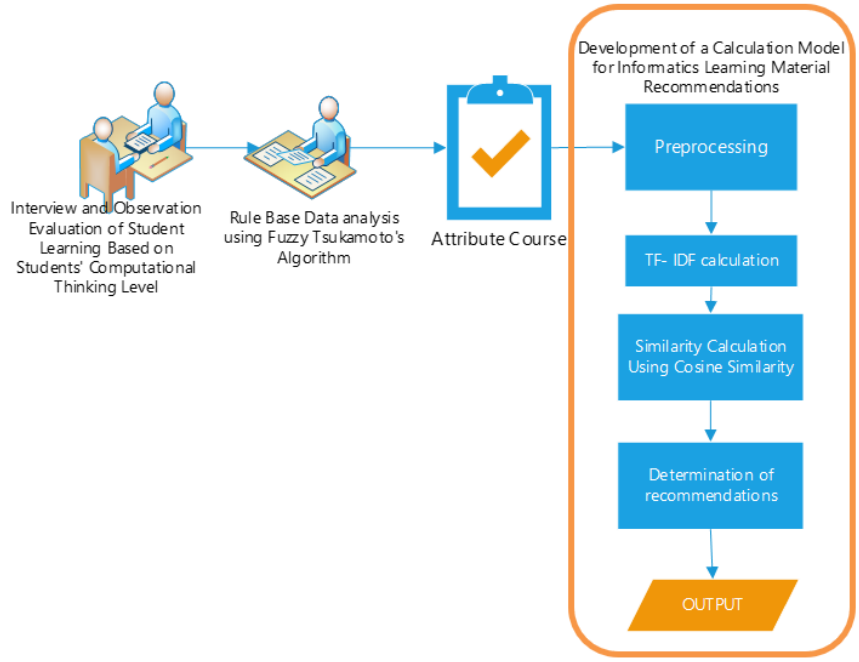

Figure 5.
Content-Base filtering algorithm scheme.

Based on the image above, it is explained as follows:

1. Interview and Observation Evaluation of Student Learning Based on Students' Computational Thinking Level: In this process, data observations are carried out in the form of students' computational thinking scores taken from teachers who have been appointed as research assistants.

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The teacher gave an instrument test in 5 classes, the results of which were measured by 4 categories of students' computational thinking.

2. Rule Base Data analysis using Fuzzy Tsukamoto's Algorithm: From the results of students' computational thinking data, it was analyzed again with rule base data using Fuzzy Tsukamoto's algorithm. The data rule base is grouped into 4 categories.
3. Attribute Course: Once the attributes are obtained, the attributes will be processed by the content-based filtering algorithm.
4. Development of a Calculation Model for Informatics Learning Material Recommendations: The model calculation process is carried out to provide material recommendations that are in accordance with the students' computational thinking criteria.
5. Output: recommendation results and recommendation accuracy test.

3.2. System Analysis

Based on the interviews and observations conducted, a system of recommendations for final project supervisors is needed for students who submit final projects. The problem that occurs is that lecturers have a lot of research documents and UPP submissions are so large that it is not possible to conduct field examinations that follow student submissions based on research documents and UPP.

3.2.1. System Planning

The design made in this study includes the design of a Data Flow Diagram and Table Structure Design.

3.2.2. Data Flow Diagram

In system design, a structured design model is used. In modeling the system to be built, the design used is a data flow diagram (DFD).

3.2.3. DFD Level 0

System users are users or admins who import student computational thinking data and student material data. The output produced from the recommendation system is to provide recommendation data and prediction accuracy test data. Figure 6. is a DFD Level 0 Recommendation System.

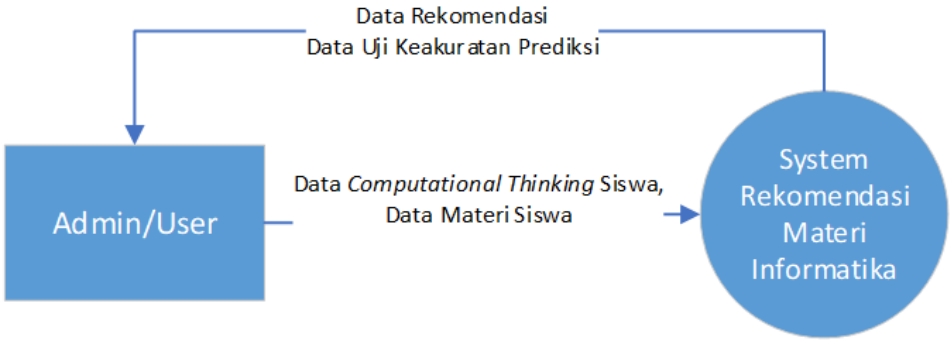

Figure 6.
DFD level 0 recommendation system.

3.2.3. DFD Level 1

From the decrease in DFD Level 0, the processes owned by the system in DFD Level 1 will be further described. The process owned by the system includes uploading student files, uploading material files, choosing student names, getting recommendations, and testing the accuracy of recommendations. Figure 7. represents the DFD Level 1 of the recommendation system.

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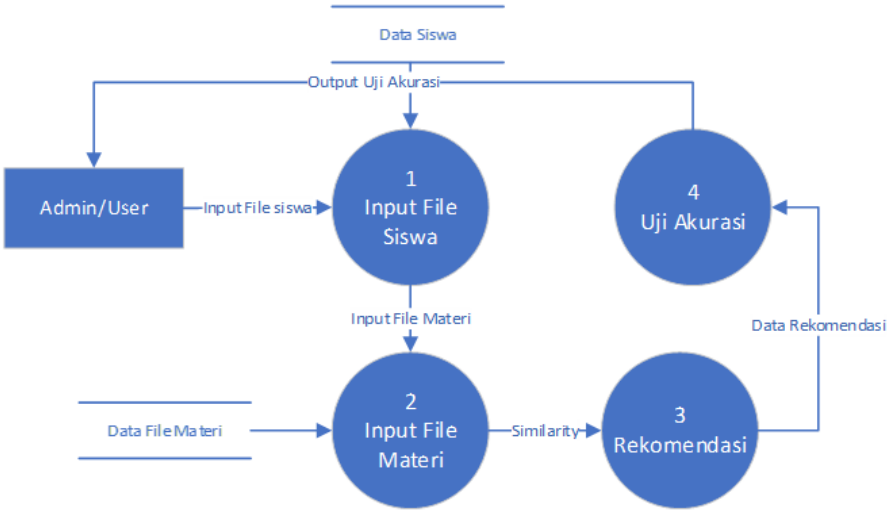

Figure 7.
DFD level 1 recommendation system.

3.2.4. DFD Level 2 Recommendation Process

The material recommendation process is taken from the data store owned by Sintesys. Document extraction through the process of tokenization, stopword removal, stemming, and weighting. The extraction results in the form of terms that have weights will be compared with material documents using the cosine similarity approach. In contrast to lecturer research documents, the results of document extraction are not included in the database. The output of this process is a recommendation for informatics materials. Figure 8. is DFD Level 2 of the recommendation process.

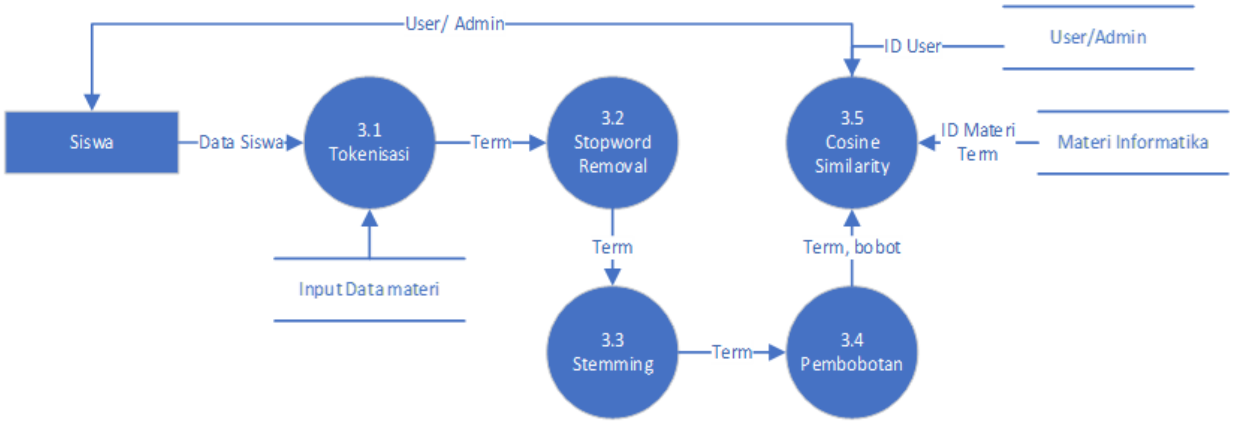

Figure 2.
DFD level 2 DFD level 2 recommendation process.

3.2.5. System Implementation

In the implementation part, the process of applying the design results into the software is carried out. The following are the results of the implementation that has been carried out. The required interface includes a home interface that contains a button to upload a student table, upload a material table, select a student name, display material recommendations, and calculate the accuracy of recommendations. Figure 9. Informatics Material Recommendation System Interface Display and Figure 10. Interface display of recommendation accuracy test system.

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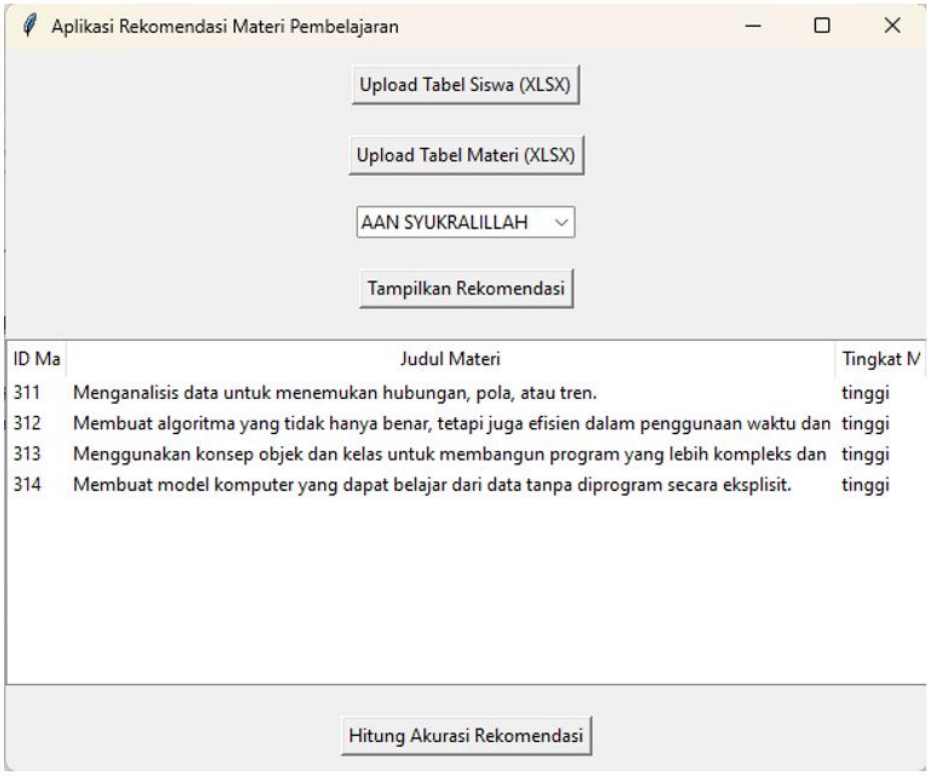

Figure 9.
Informatics material recommendation system interface display.

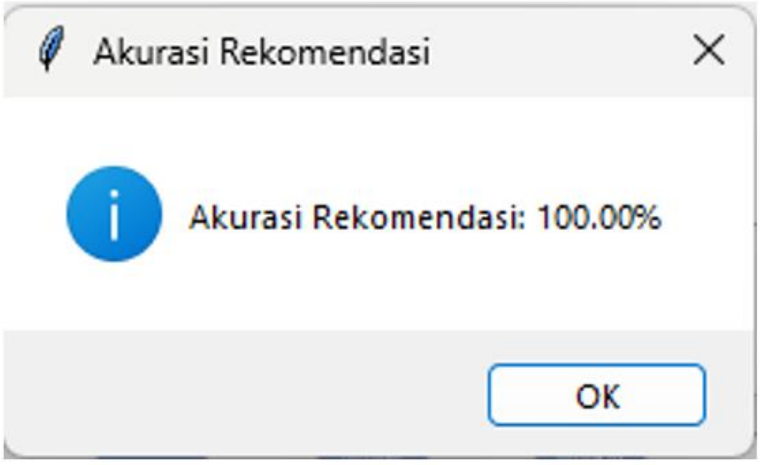

Figure 3.
Recommendation accuracy test system interface display.

4. Conclusion

The system is built by displaying the results of material recommendations and the results of the accuracy test of student material recommendation scores based on students' computational thinking. The processes carried out are tokenization, stopword removal, stemming, and weighting. The results of the extraction were then compared using the cosine similarity approach. The greater the cosine-similarity value produced, the more similar the two data are, so that the material recommendations will

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be based on the smallest cosine-similarity value between the extraction of student recommendation data. The system built has met the needs of functionality that answer the results of the problem analysis determined at the beginning of the research. This is by the results of system functionality testing carried out using black box testing. The system has been by the plan.

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References
[1] X. Tang, Y. Yin, Q. Lin, R. Hadad, and X. Zhai, "Assessing computational thinking: A systematic review of empirical studies," *Comput. Educ.*, vol. 148, p. 103798, 2020, doi: 10.1016/j.compedu.2019.103798.
[2] R. Wiryasaputra, A. Salomo, N. Sevani, and Seruni, "Peningkatan Pola Berpikir Komputasi pada Siswa/i SMAK MATER DEI Melalui Bahasa Pemrograman Java dan Python," *Servirisma*, vol. 2, no. 2, pp. 127–145, 2022, doi: 10.21460/servirisma.2022.22.28.
[3] W. C. Kuo and T. C. Hsu, "Learning Computational Thinking Without a Computer: How Computational Participation Happens in a Computational Thinking Board Game," *Asia-Pacific Educ. Res.*, vol. 29, no. 1, pp. 67–83, Feb. 2020, doi: 10.1007/S40299-019-00479-9/METRICS.
[4] T. Hidayat, S. Purnomo, S. Hadi, and Setuju, "ANALISIS MODEL PEMBELAJARAN UNTUK MENINGKATKAN HASIL BELAJAR MERDEKA BELAJAR SISWA SMK," vol. 003, no. xx, pp. 1–16, 2022.
[5] Halimah Nurul, Hadiyanto, and Rusdinal, "Analisis Pembelajaran Berdiferensiasi Sebagai BentukImplementasi Kebijakan Kurikulum Merdeka," *Pendas J. Ilm. Pendidik. Dasar*, vol. 8, no. 1, pp. 5019–5033, 2023.
[6] Z. Fitri and E. Utaminingsih, "Penerapan Metode Computational Thinking Pada Kurikulum Aceh Untuk Mencapai Kognitif," *J. MathEducation Nusant.*, vol. 4, no. 1, pp. 60–73, 2021, [Online]. Available: https://jurnal.pascaumnaw.ac.id/index.php/JMN
[7] R. M. Cacho, "TPCK assessment of pre-service teachers toward enhancing teacher educators' modeling," *Asian J. Educ. E-Learning*, vol. 2, no. 5, pp. 349–356, 2014.
[8] Safriana, Z. Fitri, and F. W. Ginting, "Implementation of Fuzzy Tsukamoto Method in Analyze Science Teacher ' s Technological Pedagogical Content Knowledge," vol. 11, no. 2, pp. 276–287, 2023.
[9] J. R. Pulungtana and Y. Dwikurnaningsih, "Evaluasi Kinerja Mengajar Guru IPS Dalam Mengimplementasikan TPACK," *J. Ilmu Sos. dan Hum.*, vol. 9, no. 1, pp. 146–155, May 2020, doi: 10.23887/JISH-UNDIKSHA.V9I1.24672.
[10] T. Nafaridah, A. Ahmad, L. Maulidia, M. Ratumbuysang, and E. M. Kesumasari, "Analisis Kegiatan P5 sebagai Penerapan Pembelajaran Berdiferensiasi pada Kurikulum Merdeka Era Digital di SMA Negeri 2 Banjarmasin," *Semin. Nas. PROSPEK II*, no. Prospek Ii, pp. 84–97, 2023.
[11] J. * Yu, Z. Xiong, Q. Bao, and X. Ning, "Design of an algorithm for recommending elective courses based on collaborative filtering." IOS Press, 2022. doi: 10.3233/JCM-226350.
[12] C. Huang, R. Chen, and L. Lin, "English Teaching Resource Recommendation Algorithm Based on Collaborative Filtering Technology," vol. 4, pp. 34–40, 2022, doi: 10.23977/aduhe.2022.040606.
[13] J. Han, "A Collaborative Filtering Recommendation Algorithm Model Based on User Feature Transfer," *More than one Artic.*, vol. 18, no. November 2023, pp. 164–187, 2023, doi: https://doi.org/10.3991/ijet.v18i22.43987.
[14] U. Javed, K. Shaukat, I. A. Hameed, F. Iqbal, T. M. Alam, and S. Luo, "A review of content-based and context-based recommendation systems," *int. J. Emerg. Technol. Learn.*, vol. 16, no. 3, pp. 274–306, 2021, doi: 10.3991/ijet.v16i03.18851.
[15] d. R. Pratama, g. S. Nugraha, and r. Dwiyansaputra, "sistem rekomendasi topik penelitian menggunakan metode content-based filtering (studi kasus program studi teknik informatika) research topic recommendation system using content-based filtering method (case study of informatics engineering study program)," vol. X, no. 36, pp. 1–9, 2019.
[16] Anis Budiono and Sri Eniyati, "Sistem Rekomendasi Dosen Pembimbing Tugas Akhir Menggunakan Content Based Filtering," *J. Elektron. Dan Komput.*, vol. 16, no. 1, pp. 64–71, 2023.
[17] R. H. Mondi, A. Wijayanto, and Winarno, "Recommendation System with Content-based Filtering Method for Culinary Tourism in Mangan Application," *ITSMART J. Ilm. Teknol. dan Inf.*, vol. 8, no. 2, pp. 65–72, 2019.
[18] T. Amelia, . P., and A. Pambudi, "Rekomendasi Jurusan Kuliah Berdasarkan Minat dan Kemampuan Menggunakan Metode Content Based Filtering," *Technol. J. Ilm.*, vol. 14, no. 3, p. 245, 2023, doi: 10.31602/tji.v14i3.11336.
[19] A. Adawiyyah and S. R. Nuddin, "Penerapan Algoritma Content Based Filtering dan Frequent Pattern Growth pada Sistem Rekomendasi Program Mahasiswa Wirausaha di Universitas Negeri Surabaya," *J. Informatics Comput. Sci.*, vol. 3, no. 02, pp. 123–130, 2021, doi: 10.26740/jinacs.v3n02.p123-130.
[20] Y. et al Mulyanto, Adi; Rusyda, "COMPUTATIONAL THINKING PADA PENDIDIKAN DASAR DAN Inst it ut

Teknologi Bandung," no. December, 2020.
[21] Fakih, mansour. 2008. Analisis gender dan transformasi sosial. Yogyakarta : pustaka pelajar.

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