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Uncovering Patterns in Online Database Usage at UiTM Negeri Sembilan: A Data Mining Approach

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ABSTRACT

This study investigates online database usage patterns at Universiti Teknologi MARA (UiTM) Negeri Sembilan through a data mining approach, specifically utilizing association rule mining and the Apriori algorithm. The primary objective is to analyze user behavior in accessing 23 subscribed online databases, aiming to uncover correlations between academic programs and database access patterns. Findings reveal significant associations among databases, indicating that certain programs are more likely to access specific databases together. For instance, students enrolled in Library Management and Food Technology programs frequently accessed both Emerald Insight and ScienceDirect. The study highlights a concerning trend of decreased database usage despite rising subscription costs, emphasizing the need for improved user engagement strategies. By profiling users based on their database access, the library can tailor its services to better meet the needs of its community, ultimately enhancing the academic experience. The research underscores the importance of data mining in optimizing resource allocation and improving library services in the digital age.

INTRODUCTION

In the digital era, academic libraries serve as gateways to a vast array of online resources, including scholarly journals, e-books, and databases. Understanding user behaviour in accessing these online databases is essential for libraries to tailor their services effectively. Tun Abdul Razak Library (PTAR), Universiti Teknologi MARA (UiTM) is committed to providing high-quality library ser-vices, making it imperative to analyse user behaviour on subscribed online databases. This paper focuses on the usage

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patterns at Universiti Teknologi MARA (UiTM) Negeri Sembilan, which comprises three campuses located in Kuala Pilah, Seremban, and Rembau. UiTM Negeri Sembilan offers a diverse range of academic programs, spanning over 31 fields of study across eight faculties. These faculties cover a broad spectrum of disciplines, including applied sciences, sports science and recreation, administrative science, mass communication, computing, and informatics. As a prominent higher educational institution in the area, UiTM Negeri Sembilan is committed to providing comprehensive library services and resources to support the diverse needs of its student and faculty community. Utilising technology to retrieve valuable information from stored data for the purpose of enhancing library services is a worthwhile effort. Demonstrating the library's competence in disseminating knowledge to users is achieved by offering accurate and comprehensive resources (Bussaban & Kularbphettong, 2014).

In 2023, PTAR expanded its resources by subscribing to a diverse selection of 23 online databases. These databases encompass a wide range of subjects and types such as full-text databases, indexing databases, financial and librarian tools, catering to the varied academic needs of its community nationwide. The decision to subscribe to these databases reflects PTAR's commitment to providing comprehensive and up-to-date resources to support research, teaching, and learning activities across multiple disciplines. By offering access to databases spanning various subjects, including but not limited to, sciences, humanities, social sciences, and technology, PTAR aims to facilitate scholarly exploration and promote academic excellence among its users. This strategic investment in online resources underscores PTAR's dedication to fostering a dynamic learning environment and empowering its community with valuable knowledge and information.

Access to the array of subscribed online databases is streamlined through EzAccess, an efficient user authentication system implemented by PTAR. This system ensures that access to these valuable resources is restricted to authorized users, both within and outside the campus premises. Through EzAccess, PTAR maintains strict control over who can avail themselves of these databases, safeguarding the integrity of the resources and adhering to licensing agreements. Additionally, the usage statistics of these databases are meticulously managed through a MySQL Online Database Management System (ODMS). This sophisticated system meticulously tracks and records various metrics, including search queries, page views, sessions, and downloads.

However, despite the yearly increase in the subscription prices of these databases, there has been a decrease in usage. This presents a significant challenge for the library, as it strives to provide valuable resources to its community while also managing its budget effectively. In this context, a data mining project can provide valuable insights into the usage patterns of these databases. By understanding these patterns, PTAR can make informed decisions to the stakeholders about resource allocation, potentially leading to cost savings and improved user engagement.

There is a significant amount of ignorance among undergraduate students regarding the online database services that are made available by institutions, as stated by Azlan et al. (2016). However, even though these services are utilised by postgraduate students and professors to a significant degree, undergraduate students are not as enthusiastic about them. As a result of their lack of familiarity with online resources, the poll discovered that a significant number of undergraduate students rely on alternative information sources. Furthermore, according to Azlan et al. (2016), undergraduate students prefer search engines over online databases because they are uninformed of the existence of the latter and the significance of the former. The fact that there is a disparity in awareness highlights the significance of making focused efforts to educate and acquaint undergraduate students with the availability of online database services supplied by universities as well as the benefits that these services provide. It is possible for educational institutions to assist undergraduate students in making more informed decisions on their information-seeking techniques by increasing awareness of accessible resources and providing support on how to access and utilise these resources.

The objective of this article is to analyze the usage patterns of online databases at Universiti Teknologi MARA (UiTM) Negeri Sembilan using data mining techniques. The study seeks to uncover correlations between academic programs and database access patterns, ultimately enabling the library to optimize its resources and improve user engagement. Through this research, libraries can better manage outreach strategies and enhance the academic experience for students and faculty. Therefore, this paper seeks to answer the following review question: What are the most prevalent usage patterns of online databases? Is it common for students to access specific databases in conjunction?

LITERATURE REVIEW

The advent of data mining in academic libraries has transformed the way these institutions manage their vast digital collections and understand user behavior. Academic libraries, historically tasked with providing access to knowledge resources, now face the additional challenge of processing, analyzing, and utilizing large amounts of data generated from user interactions and resource usage. This section reviews pertinent literature, examines how libraries are applying data mining, which offers numerous methods for extracting significant patterns from data, enhancing the knowledge discovery process, and provides a thorough analysis of its current and prospective usage in information management.

The use of data mining in academic libraries is well-documented, particularly in its ability to analyze user behavior and optimize library services. The application of the Apriori algorithm in this study is grounded in earlier research that has demonstrated its effectiveness in identifying frequent patterns in transaction data (Agrawal & Srikant, 1994). Krishnamurthy and Balasubramani (2014) underscore the role of data mining in uncovering hidden knowledge stored in library databases, which can be leveraged to enhance both the efficiency and effectiveness of library operations. Similarly, Siguenza-Guzman et al. (2015) argue that by analyzing patterns in users' information-seeking behaviors, libraries can tailor their collections to meet actual user needs, thus improving service delivery. These early studies laid the foundation for a growing body of research that highlights the potential of data mining for improving resource management and user engagement.

Big data analytics has become relevant for academic libraries. Researchers have analyzed the concept of big data, its sources, features, and relevance to libraries. Case studies from around the world demonstrate successful applications of big data in library contexts (Tella & Kadri, 2021). Libraries are now exploring more sophisticated methods such as user profiling and predictive modeling to enhance their service offerings (Joseph et al., 2019). The work of Dhanalakshmi et al. (2016) also underscores how libraries can benefit from combining data mining with other methodologies like machine learning to analyze resource usage data. By identifying co-usage patterns of digital resources, libraries can better understand which resources are accessed together, informing decisions about database subscriptions and marketing efforts (Ajibade & Muchaonyerwa, 2022). In particular, emerging trends such as artificial intelligence-driven analytics and real-time data processing are providing libraries with unprecedented capabilities to personalize services and anticipate user needs (Khademizadeh et al., 2022). Several studies highlight the role of data mining in optimizing library services. A systematic review conducted by Khademizadeh et al. (2023) emphasizes how academic libraries can use data mining techniques to improve decision-making, resource allocation, and user service optimization. The study highlights that data mining uncovers hidden patterns in user behavior, offering libraries actionable insights into collection development and resource management.

The data mining technique of association rule mining identifies significant relationships or correlations between variables in massive datasets. The Apriori algorithm, a popular technique in association rule mining, is widely used across various industries to uncover hidden connections between products (Deniz & Geyik, 2015). By analyzing transaction data, association rule mining can reveal valuable insights, such as the frequency of jointly purchased items, enabling organizations to make informed decisions about consumer segmentation, product positioning, and marketing strategies. The Apriori algorithm operates on

the principle that any non-empty subsets of a frequent itemset must also be frequent, generating association rules based on minimum support and confidence levels. Market basket analysis, a key use of association rule mining, helps find connections between frequently bought items by individual consumers.

Market basket analysis, also known as association rule mining, is a powerful data mining technique utilized to identify correlations between regularly purchased products by individual consumers (Arora et al., 2022). By analyzing transaction data, market basket analysis helps organizations understand consumer preferences, optimize product placement, and develop targeted marketing strategies (Arora et al., 2022). Association rule mining methods, such as the Apriori algorithm, are commonly employed in market basket analysis to identify significant patterns and correlations in transaction data. This analysis enables businesses to offer personalized recommendations, streamline inventory management, and enhance the overall customer purchasing experience. Organisations that wish to increase revenue and customer contentment by capitalising on consumer purchasing patterns will find market basket analysis to be an invaluable instrument.

In library usage mining, association rules have emerged as a popular strategy due to the large volume of operational records typically found in library usage data (Hajek & Stejskal, 2017). By leveraging association rules, libraries can identify relevant patterns and correlations in their usage data, providing valuable insights into user behavior and preferences. This allows libraries to optimize resource allocation, improve the user experience, and adjust services to meet the evolving needs of their patrons (Hajek & Stejskal, 2017). Association rule mining offers libraries a powerful tool to enhance their operations and better serve their users in an increasingly digital environment.

One significant area of focus is online database usage analysis (Rafique et al., 2021; Rafique et al., 2024). Research by Rafique et al. (2018) found that users in academic institutions tend to favor broader, multi-disciplinary databases over subject-specific ones, with platforms such as Elsevier, Springer, and Scopus being more frequently accessed than niche databases. This pattern reflects users' preference for comprehensive resources that offer a wide range of academic content, and it has important implications for how libraries manage their subscriptions and resources. Rafique et al. (2019) further suggest that libraries should consider these usage patterns when deciding which databases to renew or replace, as well as in developing targeted literacy programs to promote lesser-used resources.

Another growing trend is the use of data mining techniques to enhance user engagement. By analyzing user interactions with digital platforms, libraries can develop personalized services, such as resource recommendations based on past behavior. This approach, as highlighted by Arshad and Ameen (2017), is increasingly common in academic libraries as they seek to adapt to the evolving needs of their users. In particular, the integration of data mining with user experience design allows libraries to refine their services and improve the overall satisfaction of their patrons.

The application of data mining in academic libraries presents numerous opportunities for improving the efficiency and relevance of library services. By leveraging techniques such as association rule mining and pattern recognition, libraries can gain deeper insights into user behavior, helping them anticipate future needs and optimize resource allocation. For example, the use of data mining to analyze loan records or online database usage can reveal which resources are most valuable to users, guiding libraries in making informed decisions about acquisitions and subscriptions (Silwattananusarn & Kulkanjanapiban, 2020). This data-driven approach ensures that library collections remain relevant and aligned with user demand.

Moreover, data mining facilitates more effective marketing and outreach efforts. By understanding which resources are underutilized, libraries can target specific user groups with tailored promotional campaigns, increasing the visibility and usage of those resources. Personalized recommendations, similar to those used in e-commerce, can also enhance user engagement by directing individuals to materials that match their research interests. Such strategies not only improve the user experience but also help libraries maximize the return on investment in their digital resources.

METHODOLOGY

Association Rules Modeling (Apriori)

The methodology utilized in this study comprises two primary components. Firstly, the association rules modeling using the Apriori algorithm enables the grouping of accessed databases. By analyzing the frequency and co-occurrence of database accesses, Apriori facilitates the identification of patterns and associations among the databases accessed by students. This grouping process offers valuable insights into the relationships between different databases and the usage patterns of students.

The Apriori algorithm is a prominent algorithm that is employed to extract association rules from centralised databases. The functioning of this system entails the production of frequent itemsets followed by the development of association rules using these sets as foundation. The algorithm's effectiveness lies in its ability to systematically identify frequent itemsets of increasing length, allowing for the derivation of meaningful associations between database accesses.

C5.0 Rule Induction for User Profiling

Following the identification of database groups, the subsequent phase involves profiling the users belonging to these identified database groups. This profiling is accomplished using the C5.0 rule induction algorithm, which is a decision tree-based approach enabling the creation of rules to classify users based on their characteristics and behavior. By analyzing user attributes such as faculty, program of study, and frequency of database access, C5.0 rule induction generates rules that effectively classify users into different groups based on their database usage patterns.

The utilization of the C5.0 rule induction algorithm for user profiling provides deeper insights into the characteristics and preferences of students accessing specific database groups. These insights aid in the development of targeted strategies and interventions to enhance the academic experience of students.

Mining Tools

IBM SPSS Modeler 18.0, chosen as the primary mining tool for this study, is a machine learning tool incorporating various algorithms and techniques for data analysis, pattern discovery, and prediction. Its user-friendly interface and powerful features make it suitable for both novice and professional users. SPSS Modeler's capabilities include association rule modeling, decision tree induction, and data preprocessing, making it well-suited for analyzing the dataset and deriving meaningful insights.

Furthermore, SPSS Modeler's broad data pretreatment and purification capabilities simplify the dataset preparation process. Its ability to handle large datasets efficiently makes it ideal for analyzing the extensive dataset acquired for this study. Overall, IBM SPSS Modeler 18.0 was selected for its versatility, ease of use, and robust analytical capabilities, which enable thorough exploration and interpretation of the dataset to yield significant insights.

Dataset Attributes and Preprocessing:

The dataset used in this study comprises the number of page views recorded from 1057 students enrolled in semester 4 and 5 at UiTM Negeri Sembilan, accessing any of the 23 databases between January and August 2023. This dataset, sourced from the Online Database Management System (ODMS), provides a comprehensive set of data for analysis.

Prior to analysis, the dataset undergoes several preprocessing steps to ensure its quality and suitability for analysis. These steps include data cleaning, data selection, and data transformation, aimed at enhancing the integrity, relevance, and compatibility of the dataset for subsequent analysis techniques. The attributes of the dataset, including NAME, STUDENT_ID, FACULTY_DESC, PROGRAM_CODE, PROGRAM_DESC, PROGRAM_LEVEL, and database access indicators, are defined to provide clarity and context for the analysis. Figure 1 illustrates the data for association rules modeling. The highlighted area indicates the user's access to specific databases within the designated period, demonstrating how the data is formatted for analysis.

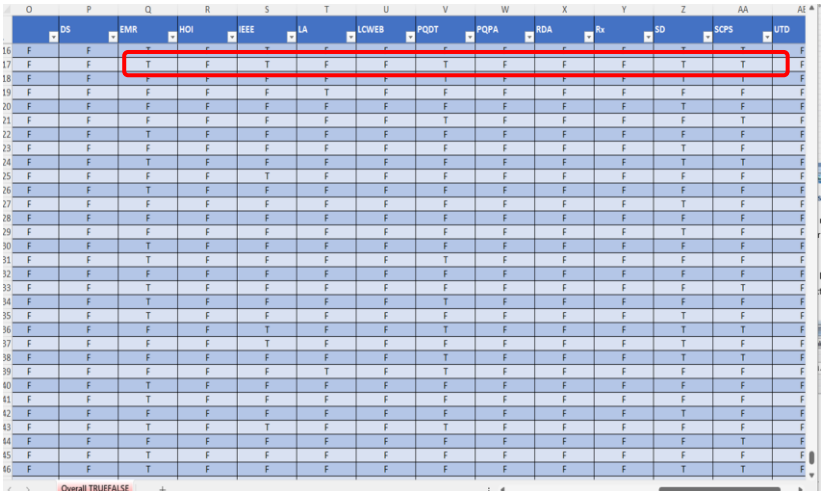

Figure 1: Data prepared for Association Rules.

Most modelling systems include customisable parameters or settings to enable control over the modelling process. To ensure the identification of an association rule, a minimum of 5 antecedents is required. The rule must have a minimum confidence level of 80%, and the antecedents must have a minimum support of 10%. The utmost important aspect is that the rules derived from this method should exclusively possess verifiable values for flags, hence rendering the rules far more comprehensible. The rules are subsequently assessed using the Rule Confidence approach. As the Evaluation measure lower bound is already included in the Minimum rule confidence option on the Model tab, it is deactivated for this measure. Partitioned data were not utilised in this technique as it focuses on discovering existing links within datasets rather than making predictions.

This study used a within-groups correlational design, predominantly assessing the relationship(s) among personality, environment, and OS. The personality was considered in terms of the Big Five personality traits, environment in terms of job-related pressures, and OS in terms of burnout and job-related stress.

RESULTS AND ANALYSIS

The methodology employed in this study yields insightful findings about user behavior, database preferences, and patterns of database access among students. Association rule mining and market basket analysis uncover significant associations and usage patterns, offering valuable insights for decision-making.

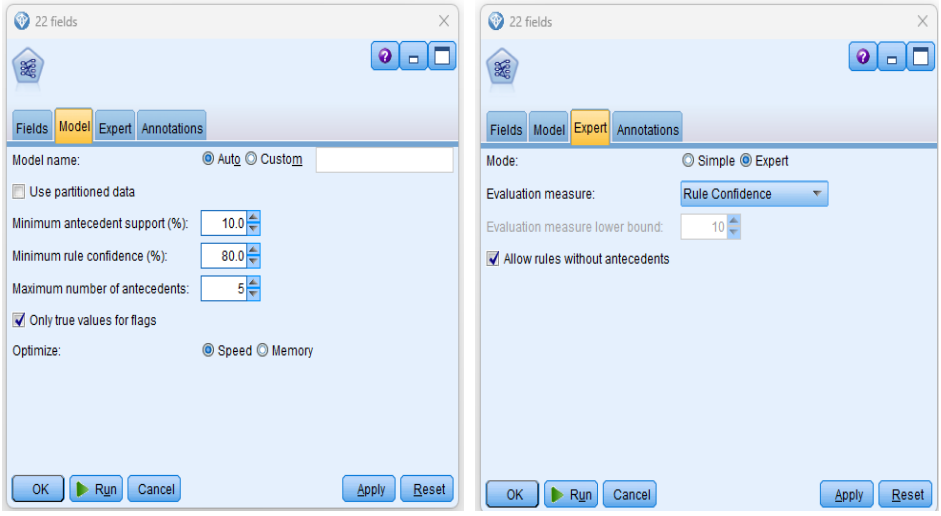

Figure 2: Parameters setting for Apriori

Table 1: Association rules derived from the data using the Apriori algorithm

Consequent	Antecedent	Support %	Confidence %
Scopus	Web of Science Emerald Insight	12.772	85.926
Scopus	Web of Science ScienceDirect Emerald Insight	10.596	84.821
Emerald Insight	ProQuest Scopus ScienceDirect	10.123	84.112
ScienceDirect	Web of Science Emerald Insight	12.772	82.963
ScienceDirect	Web of Science Scopus Emerald Insight	10.974	81.897
Emerald Insight	ProQuest ScienceDirect	13.34	81.56

Every rule consists of a consequent, which is the anticipated item, and an antecedent, which is the object or things used to create the forecast. The support of a rule refers to the proportion of transactions in the dataset that include both the consequent and the antecedent. It quantifies the frequency of the rule inside the dataset. The confidence of a rule is the proportion of transactions that contain both the antecedent and the consequent, expressed as a percentage. It quantifies the level of precision of the rule inside the dataset.

- The rule with the highest confidence is that Scopus implies Web of Science and Emerald Insight. This indicates that if a transaction includes Scopus, it is highly probable that it also includes both Web of Science and Emerald Insight. This rule exhibits a substantial degree of

elevation and capability to be put into action, suggesting that it is a robust and valuable predictor.

- The rule with the lowest confidence is ScienceDirect -> Web of Science and Emerald Insight. This implies that if a transaction includes ScienceDirect, it is less probable to include both Web of Science and Emerald Insight compared to the other rules. This rule exhibits a low level of effectiveness and applicability, suggesting that it is a feeble and less valuable predictor.
- The rule with the highest support is Emerald Insight -> ProQuest and ScienceDirect, indicating that it is the most frequently occurring rule in the dataset. Nevertheless, this rule exhibits a limited capacity for effectiveness and practicality, suggesting that it lacks accuracy and usefulness.
- The rule with the lowest support is Emerald Insight -> ProQuest and Scopus and ScienceDirect, indicating that it is the least common rule in the dataset. However, this rule has a high lift and deployability, indicating that it is very accurate and useful.

The rules demonstrated diverse correlations across Scopus, ScienceDirect, and Emerald Insight. The existence of two-way association rules indicated that a web display exclusively showcasing bidirectional associations may have effectively emphasised certain patterns within this dataset.

Continuing the investigation proved to be valuable as it uncovered intriguing patterns:

- A total of 282 occurrences were recorded where users visited both the Emerald Insight and ScienceDirect databases, suggesting a significant correlation between these two datasets.
- ScienceDirect and Scopus: A total of 247 occurrences were recorded where users visited both ScienceDirect and Scopus databases, indicating a potential connection in user requirements or academic fields.
- A total of 228 occurrences were recorded where users accessed both the Emerald Insight and Scopus databases, suggesting a potential continuity in the information offered by these databases.
- A total of 185 occurrences were recorded where users accessed both the Emerald Insight and ProQuest databases, suggesting that both databases are potentially utilised in conjunction for specific research objectives.

These robust connections indicate clusters of people categorised by the databases they have accessed. Analysing these groups using rule induction (C5.0) can offer additional insights into the characteristics of these user groups, including their academic specialties, research interests, and information-seeking behaviours. This information is extremely helpful for customising library services to cater to the individual requirements of these user groups, therefore improving user happiness and optimising resource utilisation.

C5.0 rule sets modeling has successfully identified groups of users based on the databases they accessed.

1. *Emerald Insight and ScienceDirect*:

```
Rules for T - contains 3 rule(s)
        Rule 1 for  T
                if PROGRAM_DESC = SARJANA MUDA SAINS MAKLUMAT
                    (KEPUJIAN) PENGURUSAN PERPUSTAKAAN
                then T
        Rule 2 for  T
                if PROGRAM_DESC = DIPLOMA PENGURUSAN MAKLUMAT
                then T
        Rule 3 for  T
```

if PROGRAM_DESC = DIPLOMA TEKNOLOGI MAKANAN
then T

Users who are enrolled in the programs “Diploma Pengurusan Maklumat”, “Diploma Teknologi Makanan”, or “Sarjana Muda Sains Maklumat (Kepujian) Pengurusan Perpustakaan” are likely to access both Emerald Insight and ScienceDirect databases. It’s interesting to note that students in the “Diploma Teknologi Makanan” program are particularly likely to access these databases.

2. *Emerald Insight and Scopus*:

Rules for T - contains 1 rule(s)
Rule 1 for T
if PROGRAM_CODE = IM244
then T

Users who are enrolled in the program with the code “IM244” are likely to access both Emerald Insight and Scopus databases. This suggests that these databases might cater to the specific needs of this program.

3. *ScienceDirect and Scopus:*

Rules for T - contains 1 rule(s)
Rule 1 for T
if PROGRAM_CODE in ["AS246" "CS290" "IM244"]
then T

Users who are enrolled in the programs with the codes “AS246”, “CS290”, or “IM244” are likely to access both ScienceDirect and Scopus databases. This indicates that these databases might be relevant to the courses taught in these programs.

These rules provide valuable insights into the characteristics of users within each group, based on their program of study. Further analysis and interpretation of these rules can aid in tailoring services and resources to better meet the needs of each user group, ultimately enhancing the overall user experience and satisfaction.

CONCLUSION

Utilising a data mining approach to examine patterns in library online resource access is beneficial. Particularly employing appropriate analysis to apply to the library, identify frequent patterns and correlations between items in the dataset that have a high potential for decision support implementation in the library. In summary, by implementing data mining methodologies, including rule induction and the Apriori algorithm, library services can efficiently detect trends and patterns in patron activity, thereby supplying practical and implementable knowledge for strategic decision-making. In addition, the analysis offers valuable insights regarding potential partnerships or alliances among various departments or faculties, predicated on the utilisation patterns of shared databases. Further investigation in this area could delve into supplementary determinants that impact user behaviour and enhance approaches to enhancing library services. Moreover, it would make a significant contribution to the expanding corpus of knowledge concerning user behaviour within academic library environments.

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