Journal of Computer Science

Research Paper

Association Rule Analysis of Qualitative Contribution Evaluation of Faculty Using Distributed Mining with Apriori Algorithm

Mylene Bello Ragobrio [1], Rhoderick D. Malangsa[2], Rujube Hinoguin - Hermano[3]

[1]*Eastern Samar State University, College of Computer Studies, Can-avid, Eastern Samar, Philippines.*
[2]*Southern Leyte State University, Faculty of Computer Studies and Information Technology, Sogod, Southern Leyte, Philippines.*
[3]*Southern Leyte State University, Faculty of Arts and Sciences, Sogod, Southern Leyte, Philippines.*

Article history
Received: 18 September 2024
Revised: 25 January 2025
Accepted: 9 April 2025

*Corresponding Author:
Mylene Bello Ragobrio,
Eastern Samar State University,
College of Computer Studies,
Can-avid, Eastern Samar,
Philippines;
Email:
myleneragobrio@gmail.com

Abstract: Teacher evaluation, where students serve as evaluators, is common in Philippine educational institutions. Student input based on teacher performance is considered crucial for fostering faculty development and professional advancement. The government implemented National Budget Circular (NBC) No. 461 which standardizes promotion procedures, encouraging equity and uniformity in faculty promotions among State Universities and Colleges (SUCs). Financial assistance comes from the Department of Budget and Management (DBM). The circular governs a mass promotion program with guidelines from the Commission on Higher Education (CHED) and the Philippine Association of State Colleges and Universities (PASUC) to oversee higher education standards and administration in the country. In order to find trends in faculty performance based on the Qualitative Contribution Evaluation (QCE), this study investigates the application of association rule mining, more especially the Apriori algorithm. In order to improve the quality of education that academic institutions offer, the goal is to assist them in better analyzing and comprehending the strengths and areas for improvement of their faculty. The four main components of the QCE are: (1) commitment (2) knowledge of subject, (3) teaching for independent learning and (4) management of learning. The dataset used in this investigation came from QCE Evaluation result of Easter Samar State University (ESSU), academic year 2020-2021. The QCE evaluation consisted of 4,654 instance with 7 attributes. The minimum support is 0.65 and confidence is 0.9. Using the Weka software, on the 10 rules generated, there should be given emphasize on the Management of Learning. Moreover, student evaluator chooses the Commitment as the primary parameter with the confidence of 0.88 or 88%, this implies that faculty should show consideration for students' capacity to assimilate material, integrate his learning goals with students' in a collaborative process, and remain accessible outside of class times.

Keywords: Faculty Performance Evaluation; Association Rule Mining; Apriori Algorithm

Introduction

In Philippine schools and universities, it is a standard procedure to evaluate teachers' performance. Student feedback is one of the primary means of achieving this, and it is crucial for teachers' professional development and skill improvement (Patacsil et al., 2022). In earlier years, however, State Universities and Colleges (SUCs) across the country were not covered by the National Position Classification and Compensation Plans, which

determine how government employees are paid based on a standard scale. This led to differences in how the SUCs upgraded the positions of their faculty members, resulting in inconsistencies in pay and compensation for similar positions. These disparities caused conflict and dissatisfaction among the faculty members, who felt that the compensation was not fair and equitable. There were also concerns about the subjective qualification requirements, which created imbalances and were not in line with good public administration (Alegre et al., 2019). This led to the issuance of the National Budget Circular (NBC) number 461. With financial assistance from the Department of Budget and Management (DBM), the Commission on Higher Education (CHED) and the Philippine Association of State Colleges and Universities (PASUC) collaborated to develop the policies that govern the mass promotion strategy of the NBC 461 promotion system (NBC 461 Zonal Center Region II and CAR, 2015). In short, this system guarantees that every faculty member at SUCs has an equal opportunity to be considered for promotion at the end of each cycle. How well a faculty member satisfies the requirements listed in the official guidelines determines their advancement in rank. As a result, it acts as an outside motivator, pushing educators to advance their careers (Esponilla et al., 2020).

The NBC 461 evaluation is divided into two main components, the Common Criteria Evaluation (CCE) and the Qualitative Contribution Evaluation (QCE). The recruitment, classification, and promotion of a faculty are primarily based on the CCE, which is a set of criteria used to evaluate the performance and accomplishments of a faculty member during the evaluation period (NBC 461 Zonal Center Region II and CAR, 2015).

On the other hand, the QCE serve as a reliable measure for ranking faculty among public tertiary institutions. The Teaching Effectiveness QCE, which consists of four sections, specifically (1) commitment, (2) knowledge of subject, (3) teaching for independent learning, and (4) management of learning, is required for faculty candidates aiming to advance to the higher sub-ranks of Instructor, Assistant Professor, and Associate Professor positions. For those seeking to be promoted to a full-fledged professor, additional components on research, extension, and production are to be included in the assessment (NBC 461 Zonal Center Region II and CAR, 2015).

Faculty promotion using the NBC 461 guidelines provides feedback to faculty members on their strengths and weaknesses, helping them to identify areas where they need to improve and areas where they excel. This can motivate them to strive for better performance and contribute to the overall success of the university. Likewise, understanding how well employees are performing in their roles depends heavily on evaluating their performance. In academic institutions, this process is particularly crucial for determining how effective these faculty members teach and contribute to the university. Colleges and universities are gathering enormous volumes of data these days and analyzing this data to craft more informed, fact-based choices (Dela Fuente & Dela Fuente, 2022). However, safeguarding sensitive data has never been more important and at the same time difficult in our increasingly digital world (Malangsa & Bacalla, 2015). Data analytics becomes crucial at this point. Academic institutions are looking into new applications of analytics in the field for research and development. Academic analytics, which focuses on assisting educational institutions in using data to support wise financial and operational decisions, is one important area (Angeline, 2013; Dela Fuente & Dela Fuente, 2022)

Nowadays, extracting valuable insights by identifying pertinent patterns from massive databases is largely dependent on data mining. Knowledge Discovery in Databases (KDD), which blends methods and tools from database systems, statistics, and machine learning, is utilized to make sense of such complicated data. This KDD method, an educational data mining, is being applied in the field of education to delve deeper into school-related data and uncover insights that might otherwise go overlooked. Institutions can use these findings to enhance their instruction, student support, and decision-making (Malangsa & Bacalla, 2015).

Association rule mining is one of the many data mining techniques that is most useful in a variety of applications. The goal of this method is to find intriguing correlations between variables in big datasets. A rule must simultaneously satisfy certain requirements for minimum support and minimum confidence in order to be deemed legitimate. The process typically involves two steps: first, frequent itemsets are identified using the minimum support, and then rules are generated from those itemsets that satisfy the necessary degree of confidence (Angeline, 2013). Since its initial introduction by Agarwal, this approach has changed as a number of algorithms have been developed to increase its effectiveness. The most popular algorithms for extracting recurring patterns

from data are Apriori, Eclat, and FP-Growth. These algorithms can handle both frequent and infrequent data, but they frequently produce many rules, particularly when high minimum support and confidence levels are applied. Association rule mining is still a potent tool in educational analytics and other domains in spite of this difficulty.

In order to identify trends in faculty performance based on the Qualitative Contribution Evaluation (QCE), this study uses association rule mining, more specifically, the Apriori algorithm. Recognizing these trends, academic institutions can learn a great deal about the performance of their faculty members, which can direct efforts to improve the effectiveness of their instruction and, eventually, the standard of education that students receive. QCE composed of four sections, specifically, (1) commitment (2) knowledge of subject, (3) teaching for independent learning and (4) management of learning. Strong student outcomes and effective job placements across a range of programs are the responsibility of academic institutions through the faculty members. Consequently, the teaching performance of these faculty members is of high importance to better assist students in achieving academic outcomes. However, many institutions find it difficult to conduct in-depth analyses of faculty performance, especially when using the QCE system. These issues may affect the institution's overall performance and standing. The purpose of this study is to determine which QCE sections or indicators most accurately represent a faculty member's efficacy. Finding significant performance patterns is the aim of using an analytics approach based on association rules. The suggested model makes use of the advantages of associative analytics to help State Universities and Colleges (SUCs) in the Philippines make better-informed, data-driven decisions.

Literature Review

Higher education institutions are increasingly exploring patterns through data mining to help them remain competitive in a changing academic environment, in addition to encouraging wiser decision-making. Presently, scholars are interested in the rapidly expanding field of Educational Data Mining (EDM) (Malangsa & Bacalla, 2015; Malangsa, 2014; Agrawal et al., 1993). Sun et al. (2017) looked at academic performance and student graduation records using a combination of association rule mining and hierarchical association analysis. They found significant relationships between core courses and necessary skills, which helped colleges and universities create better programs using a project-based curriculum teaching mode.

Scores from various professional courses were examined using the association rule algorithm, which was used to determine how well these courses meet industry demands. Teachers can improve their teaching strategies and make significant curriculum changes with the help of this analysis's insightful findings (Li et al., 2018). Similarly, the Apriori algorithm was employed to scrutinize the students' learning effect by determining the correlation between different courses and early academic difficulties (Diao et al., 2019).

One study looks into how data mining methods, particularly Association Rule Mining, can support educational recommender systems (Rayasad, 2017). It shows how this technique can be applied to understand better the effectiveness of internal assessments used in schools. To do this, the Apriori algorithm is used to uncover meaningful patterns unique to each class. These patterns help analyze student data more deeply and allow educators to group students based on their academic performance, which makes it easier to identify learning needs and provide timely support. This classification takes into account things like class attendance, internal assessment results, and assignment completion. Teachers can more accurately forecast student performance and make well-informed decisions to support learners by spotting patterns within these factors (Long & Zhu, 2022).

The Apriori algorithm has been applied to identify patterns that influence students' interest in literature courses, and allow these insights to be connected with current teaching practices for a more meaningful analysis (Han & Kamber, 2006). The outcomes show that this approach is not only feasible but also highly effective, especially when used within the limitations of the available resources and infrastructure.

Materials and Methods

Data Mining Technique

Data mining is a process of mining knowledge from datasets stored in a fixed form (Agrawal et al., 1993). Data mining focuses on real-world applications and involves four stages, namely, the data preparation stage, the determination of mining mode stage, the development stage, and the evaluation stage. Figure 3 provides the simplified flowchart of the data mining techniques.

Distributed Mining

Distributed rule mining leverages the principles of traditional association rule mining algorithms in a distributed computing environment to efficiently handle

large datasets and cloud-based resources (Mottalib et al., 2011).

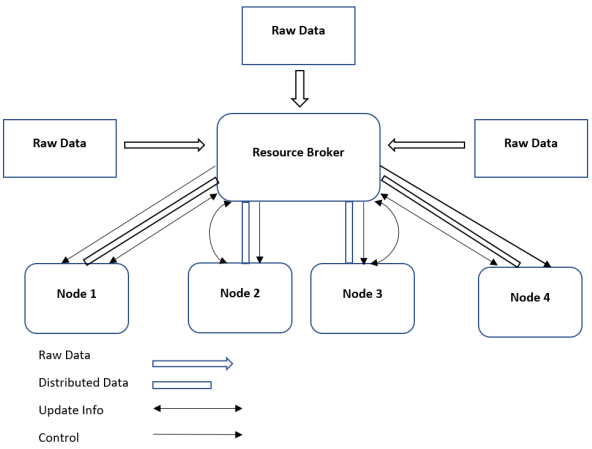

Fig. 1. The Architecture of Distributed Mining

This approach enhances the efficiency of data mining algorithms by distributing the dataset among nodes and applying the Apriori algorithm to identify frequent item sets.

As shown in Figure 1, distributed rule mining utilizes multiple nodes or processors in parallel to mine patterns across subsets of data. The recent trend in research on this field is shifting towards advancing algorithm efficiency, flexibility, scalability, and enhancing the rule mining process (Biswas et al., 2019).

Apriori Algorithm

The association rule algorithm is the most used in modern data mining. The basic principle of the algorithm is to assess the impact on other phenomena by examining specific phenomena. Generally, the rules required by load parameters are called strong association rules.

The Apriori algorithm is a standard algorithm of association rule mining (Frank et al., 2016), given in Fig. 2. The Apriori Algorithm is used for finding frequent k-itemsets. A kitemset is an itemset containing k items. Support is the number of transactions that contain a particular itemset observation.

In rule induction, a state resembles a candidate rule and operators resemble generalization and specialization operations that transform one candidate rule into another.

Support is a metric used to measure how frequently an item appears in the dataset relative to the total number of transactions. Thus, higher support indicates a more noteworthy presence of the itemset in the dataset. Support tells us how frequently a particular item or combination of items appears in all the transactions.

L_1= {large 1-itemsets};
for ($k = 2$; $L_{k-1} \neq \emptyset$; k++) **do begin**
C_k= apriori-gen(L_{k-1}); //New candidates
forall transactions $t \in D$ **do begin**
C_t= subset(C_k, t); //Candidates contained in t
forall candidates $c \in C_t$ **do**
c.count++;
end
L_k= { $c \in C_k \mid c.\text{count} \geq \text{minsup}$ }
end
Answer = $\bigcup_k L_k$;

Fig. 2. The Apriori Algorithm (Frank et al., 2016)

Confidence is a metric used to evaluate the likelihood that an item A is purchased when item B is purchased. In addition, confidence provides insight into the strength of the association between two items and tells us how frequently they occur together.

Lift is a metric used to calculate how much more likely two items are to be purchased together compared to being purchased independently. A lift greater than 1 suggests a strong positive association. Lift shows how strong the connection is between items.

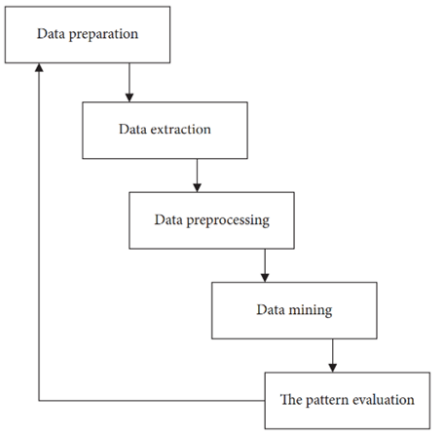

Fig. 3. Data Mining Flowchart

Data Preparation

Data is the focal aspect of data mining, so the preliminary preparation of data is the crucial stage in every data mining operation, as illustrated in Figure 3. Standardization of data from different regions and varying data types is also crucial for efficient data mining tasks. The dataset used in the study was stored

in Excel files, and data cleaning was also performed by filling in other missing values.

Data Extraction

Data mining researchers extracted the required data in CSV format, deleted non-valuable attributes, explored the prepared integrated data, and determined the value and scope of the data. In this study, the researchers strictly followed the principle of data extraction to ensure the realization of task objectives.

Data Preprocessing

Data preprocessing was directly employed after cleaning the data gathered. Data preprocessing operations included the tokenization, filtering of stop words, case transformation, and stemming. The dataset was also transformed from numerical to categorical data type.

Data Set

The data set was obtained from the QCE Evaluation result of Easter Samar State University (ESSU), academic year 2020-2021. The QCE evaluation consisted of 4,654 instances with seven (7) attributes.

Data Transformation

As shown in Table 1, the distribution of raters in the QCE indicates that there were 30 student respondents per faculty. In this study, the 3,600 students were randomly selected in the academic year.

Table 1. The distribution of raters

Rater	Number	Percentage
Student	3,600	77.35%
Peer	654	14.05%
Supervisor	200	4.30%
Self	200	4.30%
Total	**4, 654**	**100%**

Table 2 presents the evaluation instrument of the QCE, which is divided into four parts, each consisting of five (5) indicators. In this study, the corresponding descriptive value is used instead of the numerical value.

Pattern Recognition

Association Rule Mining was utilized in determining the pattern recognition. A strong relationship between or among items means that itemsets must satisfy the set value for the minimum threshold for support and confidence.

The formula is given below:

SUPPORT = occurrences of [A, B] /total number of transactions (1)

CONFIDENCE [A,B] = occurrences of [A,B] /total number of [A] (2)

Table 2. Instrument Evaluation

Parameter	Number	Nominal
Commitment		
1. Demonstrate sensitivity to students' ability to absorb content information	1-5	(Outstanding, Excellent, Very Good, Good, Needs Improvement)
2. Integrates sensibility his learning objectives with those of the students in collaborative process	1-5	(O, E, VG, G, NE)
3. Makes himself available to students beyond official teaching hours	1-5	(O, E, VG, G, NE)
4. Coordinates student needs with internal and external enabling groups	1-5	(O, E, VG, G, NE)
5. Supplements available resources	1-5	(O, E, VG, G, NE)
Knowledge of Subject		
1. Explains the subject matter without completely relying on the prescribed rating	1-5	(O, E, VG, G, NE)
2. Explains subject matter with depth	1-5	(O, E, VG, G, NE)
3. Integrates topics discussed in the lesson and relates the topic being discussed to concepts previously learned by the students in the same course	1-5	(O, E, VG, G, NE)
4. Relates the subject matter to other pertinent topics	1-5	(O, E, VG, G, NE)
5. Raises problems and issues relevant to the topic(s) discussion	1-5	(O, E, VG, G, NE)
Teaching for Independent Learning		
1. Create teaching strategies that allow student to practice using concepts they need to understand (interactive discussion)	1-5	(O, E, VG, G, NE)
2. Provides exercises which develop analytical thinking among the students	1-5	(O, E, VG, G, NE)
3. Allow the students to create their own course with the use of well-defined objectives and realistic student-professor rules	1-5	(O, E, VG, G, NE)
4. Enhances students' self-esteem through the proper recognition of their abilities	1-5	(O, E, VG, G, NE)
5. Allows students to make their own decisions and be accountable	1-5	(O, E, VG, G, NE)
Management of Learning		
1. Creates opportunities for extensive contribution of students (e.g. break class into dyads, triads, or buzz/task group)	1-5	(O, E, VG, G, NE)
2. Assumes roles as facilitator, resource, coach, inquisitor, integrator, referee in drawing students to contribute to knowledge and understanding of the concepts at hand	1-5	(O, E, VG, G, NE)
3. Designs and implements learning conditions and experience that promote healthy exchange and / or confrontations	1-5	(O, E, VG, G, NE)
4. Structures/ re-structures learning and teaching-learning context to	1-5	(O, E, VG, G, NE)

enhance attainment of collective learning objectives 5. Stimulates students' desire and interest to learn more about the subject matter	1-5	(O, E, VG, G, NE)

Weka version 3.8.5 software was used in this study; it is an open source software issued under the GNU General Public License. Moreover, it is a collection of algorithms for data mining jobs. It has tools for data preparation, classification, regression, clustering, association rules mining, and visualization.

Results and Discussion

Table 3. The parameters used in this study

Apriori Parameters	
Minimum Support	0.65
Confidence	0.90
Number of Rules	10.00
delta	0.05

Best Rules Found:

1.If the Management of Learning is Outstanding then the Commitment is Outstanding - confidence 88%

2.If the Evaluator is Student then Commitment is Outstanding - confidence of 88%

3.If the Teaching for Independent Learning is Outstanding then Commitment is Outstanding - confidence 88%

4. If the Evaluator is Student then Teaching for Independent Learning is Outstanding - confidence 88%

5. If the Knowledge of Subject is Outstanding then Commitment is Outstanding - confidence 88%

6. If Commitment is Outstanding then Teaching for Independent Learning is Outstanding - confidence 88%

7. If Management of Learning is Outstanding then Teaching for Independent Learning is Outstanding-confidence 88%

8. If Management of Learning is Outstanding then Knowledge of Subject Matter is Outstanding-confidence 88%

9. If Management of Learning is Outstanding then Evaluator is Student -confidence 85%

10. If Knowledge of Subject is Outstanding then Evaluator is Student - confidence 85%

Rule Analysis

Management of Learning wherein; faculty should adopt roles as facilitator, coach, integrator, and referee in conveying students to contribute to knowledge and understanding of the concepts at hand, implements learning experience that promote healthy exchange and/or confrontations, structures/re-structures learning and teaching-learning framework to enhance attainment of learning objectives, and arouses students' desire and interest to learn more about the subject matter. The rules inferred that when faculty Management of Learning is rated as outstanding, it is accompanied by outstanding levels of Commitment, Teaching for Independent Learning, and Subject Knowledge, with the evaluators being students. A significant correlation was found between effective Management of Learning and other key components, including Commitment, Teaching for Independent Learning, and Subject Knowledge, indicating that all these aspects are interdependent. A faculty member who is efficient in managing learning may be more committed to this role and, therefore, may develop better strategies that foster independent learning (Devlin & Samarawickrema, 2010). In the same way, mastery of content knowledge enables the faculty to monitor learning more effectively since one has to assess the needs of the students being taught and then design instructional strategies that will fit into their needs (Stronge, 2018). The findings also imply that mastery in one of the instructional dimensions, particularly management of learning, could enhance positively the rest of the key components of education. It strengthens the notion of coherence in faculty development as the required management competencies positively impact not only students but also overall quality improvement within the institution (Phuong et al., 2018). In addition, students in this view assumed that when the faculty provides excellent management of learning, their efforts will not be overlooked and hence be rewarded with high evaluations in the related areas (Vakili et al., 2024). This rule, therefore, supports the need for enhanced faculty development and the incorporation of students in the development of a highly efficient and comprehensive learning model.

Commitment of faculty members and the ability to teach students for independence correspond and supplement one another. This implies that when faculty members have a high commitment, they are determined to dedicate their time and efforts to formulating methods that will enhance independent learning among students. They strive to establish learning processes that motivate students to take responsibility for their learning, helping them develop thinking skills, problem-solving abilities, and a spirit of self-motivated learning. The other advantage of committed faculty members is that they can offer constant encouragement, assessment, and assistance, which are critical for learner success in an autonomous learning environment. On the same note, if teaching for independent learning is rated as outstanding, it may be an indication of a faculty's passion in ensuring that the students are empowered. This Commitment is manifested

in their concern for not merely conventionally delivering instruction, but also introducing innovative teaching techniques that are effective for students with different learning abilities, or those that foster self-mastery (Devlin & Samarawickrema, 2010). The effectiveness of independent learning pursuits also encourages faculty members to work harder, knowing that their input yields results among students. It provides positive feedback to the effort and strengthens their Commitment, which in turn fosters even more effective teaching practices. As such, outstanding Commitment and Teaching for Independent Learning complement each other. Faculty commitment leads to the provision of well-organized ways of learning independently, and the learners' effectiveness in using these ways gives the faculty the morale to continue in a circle of mutual benefits that make the learning process more fulfilling to both faculty members and learners.

When a faculty member knows their subject thoroughly, they are more likely to be highly committed to teaching. This relationship often exists because a teacher's knowledge of subject matter is a prerequisite for effective classroom instruction (Stronge, 2018). A faculty with content knowledge can easily entice learners, give substantive responses to questions, and modify the process according to learners' needs, all of which make the learning process more exciting and successful. This shows their dedication to continuing education and their passion for the work they do. Faculty members who are willing to dedicate their time and effort to mastering a particular subject area are probably more inclined to ensure they keep up to date with the newer technologies and teaching methodologies (San-Martín et al., 2020). These individuals are very interested in their chosen subject, and that translates into a desire to pass on that knowledge to students, which in turn makes them more dedicated teachers.

Conclusion

The study has been developed to analyze the discovered rules against users' knowledge. Discovered rules can be pruned to remove redundant and insignificant rules

Based on the above rules generated, there should be given emphasize on the Management of Learning wherein; faculty should create chances for extensive contribution of students, assumes roles as facilitator, resource, coach, and referee in conveying students to contribute to knowledge and understanding of the concepts at hand, designs and implements learning experience that promote healthy exchange and/or confrontations, structures/re-structures learning and teaching-learning context to enhance attainment of learning objectives, and arouses students' desire and interest to learn more about the subject matter. If the faculty performs well on Management of Learning, then the other three parameters will also yield positive results.

Moreover, the student evaluator chooses the Commitment as the primary parameter with a confidence of 0.88 or 88%. This implies that faculty should exhibit sensitivity to students' ability to grasp content information, faculty incorporate sensitivity in learning objectives with those of the students in a collaborative process, and make themselves open to students beyond official teaching hours.

Acknowledgement

We thank the publisher for their support and for providing a platform to share our research with a broader audience.

Funding Information

The authors have not received any financial support or funding to report.

Author's Contributions

Mylene Bello Ragobrio: Research work, Data Collection
Rhoderick D. Malangsa: Supervise the study, Data Analysis
Rujube Hinoguin-Hermano: Research work, Interpretation of data analysis results

Ethics

This article is original with unpublished content, and the corresponding author confirms that all co-authors have approved the manuscript and that there are no ethical issues involved.

References

Agrawal, R., Imielinski, T., & Swami, A. (1993). Mining association rules between sets of items in large databases. In *Proceedings of the 1993 ACM SIGMOD International Conference on Management of Data* (pp. 207-216). ACM.

Angeline, M. D. (2013). Association rule generation for student performance analysis using Apriori algorithm. *The SIJ Transactions on Computer Science Engineering & Its Applications, 1*(1).

Alegre, G., Arcaya, R., & Masuhay, E. (2019). Teachers' reclassification under NBC 461: Burdensome and prolific. *International Journal of Innovative Science and Research Technology*, 236-238.

Biswas, S., Biswas, N., & Mondal, K. C. (2019). Parallel and distributed association rule mining algorithms: A recent survey. *Information Management and Computer Science, 2*(1), 15-24.

Dela Fuente, R. O., & Dela Fuente, R. O. (2022). Faculty performance evaluation system with application of data analytics. *South Asian Journal of Engineering and Technology, 21*, 24-31.

Devlin, M., & Samarawickrema, G. (2010). The criteria of effective teaching in a changing higher education context. *Higher Education Research & Development, 29*(2), 111-124. https://doi.org/10.1080/07294360903244398

Diao, S., Chen, L. W., Ma, Y., & Zhang, T. (2019). Application of data envelopment analysis in individualized learning of health statistics. *Chinese Journal of Health Statistics, 36*(5), 759-762.

Esponilla, F. D., Tolentino, L. K. S., Barbacena, C. B., & Portez, A. P. (2020). The National Budget Circular 461: Emerging trends in Philippines higher education promotion system. *International Journal of Evaluation and Research in Education, 9*(4), 1035-1044. https://doi.org/10.11591/ijere.v9i4.20641

Frank, E., Hall, M. A., & Witten, I. H. (2016). *The WEKA workbench: Online appendix for data mining: Practical machine learning tools and techniques* (4th ed.). Morgan Kaufmann.

Han, J., & Kamber, M. (2006). *Data mining: Concepts and techniques* (2nd ed.). Elsevier.

Li, J. L., Chu, L. Q., Gui, L., & Hu, B. (2018). Analysis and reflection on main course examination results of vocational nursing students from different sources. *China Continuing Medical Education, 10*(30), 45-47.

Long, S., & Zhu, Q. (2022). Association rule analysis of influencing factors of literature curriculum interest based on data mining. *Computational Intelligence and Neuroscience, 2022*, 1-8. https://doi.org/10.1155/2022/XXXXXXX

Malangsa, R. D. (2014). Development of face recognition time monitoring and attendance system. *Journal of Science, Engineering and Technology, 2*, 33-43.

Malangsa, R. D., & Bacalla, A. C. (2015). Performance comparison of decision stump and J48 classification algorithm on the programming skill of IT students. *Journal of Science, Engineering and Technology, 3*, 199-212.

Mottalib, M., Arefin, K. S., Islam, M. M., Rahman, M. A., & Abeer, S. A. (2011). Performance analysis of distributed association rule mining with Apriori algorithm. *International Journal of Computer Theory and Engineering, 3*(4), 484-488.

NBC 461 Zonal Center Region II and CAR. (2015). *NBC 461 operations manual*. https://usermanual.wiki/Pdf/nbc461guidelinesmanual.1636757763/view

Patacsil, F. F., Cenas, P. V., Roaring, B. F., Parrone, J. M., & Garcia, D. B. (2022). Evaluating Pangasinan State University faculty performance using associative rule analysis. *International Journal of Information and Education Technology, 12*(1).

Phuong, T. T., Cole, S. C., & Zarestky, J. (2018). A systematic literature review of faculty development for teacher educators. *Higher Education Research & Development, 37*(2), 373-389. https://doi.org/10.1080/07294360.2017.1351423

Rayasad, G. N. (2017). Association rule mining in educational recommender systems. *International Journal of Advance Research in Science and Engineering, 10*(8), 1285-1299.

San-Martín, S., Jiménez, N., Rodríguez-Torrico, P., & Piñeiro-Ibarra, I. (2020). The determinants of teachers' continuance commitment to e-learning in higher education. *Education and Information Technologies, 25*(4), 3205-3225. https://doi.org/10.1007/s10639-020-10102-3

Stronge, J. H. (2018). *Qualities of effective teachers* (3rd ed.). ASCD.

Sun, J., Zhang, W., Ren, Z. J., Wang, D. L., & Cui, Y. (2017). Practice on OBE evaluation architecture for the achievement of graduation requirements based on the engineering education accreditation system. *Tsinghua Journal of Education, 38*(4), 117-124.

Vakili, A., HajiAghajani, S., & Rashidy-Pour, A. (2024). An investigation of factors influencing student evaluation of teacher performance: A comprehensive study in Semnan University of Medical Sciences. *Koomesh, 12*(2), 93-103.