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Assessing the Impact of Class Attendance on Student's Academic Performance using Data Mining

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Abstract: Many institutions of learning encourage students to have good lecture attendance records. The belief is that an above average attendance rate will enhance student's academic performance. However, very few studies have attempted to answer questions that relate to: the actual impact of good attendance record on student's academic performance; the extent in quantitative terms of the effect of good attendance record on student's academic performance. This study reports the findings from an experimental analysis of student's attendance record and corresponding academic performance results using association rule mining. Based on the extracted patterns in rules from the five course assessed, it was discovered that the impact of class attendance on academic performance is very low. A student with >70 % attendance score can still fall into any grade between "A-F". This indicates that class attendance is not the major factor that determines student academic performance but other key factors such as the student participation in the class, personal study and group study. The result of this case study and the recommendations is expected to provide useful information for the managements of higher institutions of learning on appropriate perspective to adopt on class attendance policies and good motivation for distance and online learning programmes.

Key words: Association rule mining, student academic performance, class attendance, data mining, leraning, Nigeria

INTRODUCTION

According to Longman Dictionary of contemporary English, academic performance can be viewed as the coursework-related performance of students who are enrolled in a university. This is mostly measured in Grade Point Average (GPA) which serves as an academic performance indicator in higher institutions of learning. Institution Academic planners depend mostly on GPA to evaluate student performance and academic progression in their academic environment (Sansgiry *et al*., 2006). The GPA is an aggregate academic performance representation of each student in different courses which stems from the student Continuous Assessment (CA) scores and the final examination scores. For example, according to laid down guidelines universities in Nigeria by the National University Commission (NUC) of Nigeria, for undergraduate students, the CA constitutes 30% of the total score in a course while the final examination constitutes 70%.

The objective of keeping attendance records in most higher institutions of learning is to ensure physical participation of students in their taught courses in order to improve the student's overall performance. At every class session, each student is expected to register attendance with a unique identification number and signature. This is achieved through different means such as electronic identification such as swiping of identification card on an RFID scanner, thumb print recognition or manual signature and roll call. This is the practice in many Nigerian higher institutions of learning because it was noticed that students interpret their academic freedom in the tertiary institutions to mean opportunity to be absent from class sessions (Ajiboye and Tella, 2006). To this effect, in order to compel student's attendance of lectures, an attendance evaluation policy has been introduced in some universities, where students who have not met the minimum expected percentage of attendance for a particular course are not allowed to participate in the examination. However, it is difficult to determine whether attendance rates serve as indicators of inherent motivation without an external cause to determine student grade (Harris, 2006). For instance, an unmotivated student forced to attend lectures is unlikely to pay attention or heartily participate in the class activities and may end up having poor grades because of lack of proper participation. Therefore, in order to justify continual

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investment in the implementation of course attendance policy, there is a need to determine the real impact of course attendance on student's academic performances and more importantly the extent of its influence on academic performance in quantitative terms. The result of this kind of study will enable relevant academic units within a university to assess the merit, effectiveness or otherwise of continual enforcement of minimum percentage attendance policy in an institution. In contrast to the statistical approaches and other methods that have been used previously in the literature, Association Rule Mining algorithm (ARM) is able to extract useful patterns from the dataset beyond the data description. Also, beyond the ability to determine the effect of class attendance on student academic performance, ARM has the capacity to determine the extent in quantitative terms the effect with the help of rule support and confidence measures. Therefore, this study has made a choice of investigating the impact of class attendance on student academic performance in specific taught courses using association rule mining approach.

Literature review

Overview of association rule mining: Association rule mining as an important application of data mining was introduced by Agrawal *et al.* (1993) to identify relationships among a set of items in a database. The relationship is based on the co-occurrence of the data item and not on the inherent properties of the data as with the functional dependencies. Association rule mining problem can be defined formally as:

Let I = {I1, I2... Im} be a set of m distinct attributes, also called literals. Let D be a database where each record (tuple) T has a unique identifier and contains a set of items such that $T \subseteq I$. An association rule is an implication of the form $X \Rightarrow Y$ where X, $Y \subset I$ are sets of items called itemsets and $X \cap Y = \phi$. Here, X is called antecedent and Y consequent.

The important measures of support and confidence are used to determine the extent and weight of the implication rules. The support (s) of an association rule is the ratio in percentage of the records that contain $X \cup Y$ to the total number records in the database. The confidence (c) of a rule is the ratio in percentage of the number of records that contains $X \cup Y$ to the number of records that contain X. If we say that $X \Rightarrow Y$ with a support of 70% and confidence of 60% it means that 70% of the entire record contain $X \cup Y$ and 60% of the records that contain X also contain Y. The model for support and confidence are represented with Eq. 1 and 2. An item set is said to be frequent if it satisfies the minimum support (s) threshold and a rule is said to be interesting it meets the minimum confidence threshold (α). The distinct attributes of the database could be binary, categorical and quantitative in nature (Srikant and Agrawal, 1996). The mining of categorical and quantitative types of attributes is called quantitative association rule mining.

$$\text{Support}(A \rightarrow B) = \frac{\sum(\Pi(A,B))}{N} \quad (1)$$

$$\text{Confidence}(A \rightarrow B) = \frac{\text{Support}(A \rightarrow B)}{\sum A} \quad (2)$$

The association rule mining problem can be divided into 2 subproblems (Agrawal and Srikant 1994) as stated in Algorithm1. There are several algorithms for generating association rule. The most common and traditional algorithm is Apriori Algorithm developed by Agrawal and Srikant (1994). The algorithm is represented by Algorithm 2.

Algorithm 1; ARM problems:

```
Input:
I, D, s, α
Output:
Association rules satisfying s and α
Algorithm:
        Find all sets of items which occur with a frequency    that is greater
than or equal to the
        user-specified threshold support, s.
        Generate the desired rules using the large itemsets which have user-
specified threshold confidence, α
```

Algorithm 2; Apriori (Agrawal and Srikant, 1994):

```
Input: I, D, s
Output: L // the set of rules
Algorithm:
//procedure LargeItemsets
        C1: = I; //Candidate 1-itemsets
        Generate L1 by traversing database and counting each occurrence of an
attribute in a
        transaction;
                for (k = 2; Lk-1≠ϕ; k++) do begin
        //Candidate Itemset generation
        //New k-candidate itemsets are generated from (k-1)   large itemsets
                Ck = apriori-gen (Lk-1);
        //Counting support of Ck
                Count (Ck, D)
        Lk = {c∈_Ck | c.count ∈_minsup}
        end
         L:= ∪kLk
```

MATERIALS AND METHODS

Quantitative association rule: Discovering of rules in quantitative and categorical data can be referred to as the quantitative association rule mining problem (Srikant and Agrawal, 1996). One the ways of dealing with a quantitative attribute is to replace it with the several

Table 1: Sample database

ID	Attendance	Results
1	70	65
2	55	71
3	49	49
4	35	51
5	60	80

Table 2: Mapping table

	Attendance					Results				
ID	>70	60-69	50-59	45-49	<45	>70	60-69	50-59	45-49	<45
1	1	0	0	0	0	0	1	0	0	0
2	0	0	1	0	0	1	0	0	0	0
3	0	0	0	1	0	0	0	0	1	0
4	0	0	0	0	1	0	0	1	0	0
5	0	1	0	0	0	1	0	0	0	0

Boolean attributes by mapping them into binary values. This will be very straight forward if the attribute contains few values such that <attibute1, value1> would be 1 if attribute1 had value1 in the original database and 0 otherwise. If the values are big, there will be need to partition the attribute value into interval partitions and map each attribute value to the corresponding new boolean attributes. The binary algorithm can then be used to discover association rules. A typical example of the procedure can be seen in Table 1 which contains the student's percentage attendance and student's sum total results in percentage (CA+examination result) and Table 2 which is representing the boolean attribute table that map each attribute value to their partitions.

These two approaches are sufficient if the description of the dataset had indicated that every tuple under consideration can only belong to one of the intervals. Otherwise, introduction of partitions can cause sharp boundary problem where the boundary data is either overestimated or underestimated. This problem is not new, it has been resolved in the literature by introducing fuzzy concept into association rule mining. This is called Fuzzy association rule mining which allows for overlapping of boundaries by tuples. Such that, a tuple can belong to two neighboring interval partitions with specified membership value within [0, 1].

Related works: Student academic performance is an indicator of the student's intellectual ability and strength. Due to the importance of GPA, a lot of submissions about factors that could affect student academic performance have been investigated in the literature (McCall *et al*., 2007; Campbell, 2011; Curtis *et al*., 2007; Rafidah *et al*., 2009; Lin *et al*., 2009; Olamiti and Osofisan, 2009). Reynol and Shelia (2012) investigated the effect of ICT (multitasking) on academic performance using hierarchical linear regression. Lindo *et al*. (2013) carried out a study on the effect of alcohol on student performance. A master's thesis by Chih (2013) investigated the effect of sleep on student academic performance for undergraduate students working in the hospitality industry as compared to those who are not working in the industry. The author used Cronbach's alpha to test the reliability of the instrument and t-test and ANOVA were used for the analysis on the SPSS platform (Chih, 2013). Holgado *et al*., (2014) investigates the impact of child labour on academic performance. For the analysis, a series of logistic regression model were adjusted and statistical package of SPSS was used as analysis tool.

Also, several researchers have analysed the class attendance and student performance from different perspectives using different methodologies. Some researchers strongly support the proposition that class attendance is capable of determining student academic performance based on their analysis. Some of such that have been reported in the literature are reviewed in this study. Obeidat *et al*. (2012), statistical analysis of variance was used to analyse the student attendance percentage, the overall Grade Point Average (GPA) and the number of credit hours that the student enrolled in a specific semester. The authors also used minitab to analyse their data in order to obtain a regression analysis model for the attendance and academic performance analysis. It was concluded from the analysis that the overall student's GPA and the attendance percentage are the most significant factors in determining the grade attained in a specific class. An analysis of class attendance and gender effect on undergraduate student's achievement in social studies course in botswana was carried out (Ajiboye and Tella, 2006). ANOVA and Student's t-test were used for the statistical analysis. An investigation into the academic effectiveness of class attendance in an intermediate microeconomic theory class was carried out by Joan and John (2003). Different analytical models like Fixed-Effects Model (FEM), the Random-Effects Model (REM) and Ordinary Least Squares (OLS) estimation for regression were used and the result showed the strong support for the proposition that class attendance has a significant effect on academic performance. Other analysis in support of the proposition could be found by Moore *et al*. (2003), Moore (2006), Devadoss and Foltz (1996), Romer (1993) and Chen and Lin (2006).

In objection to this proposition, Caviglia investigated the impact of mandatory attendance policies and absentee rates on student performance using OLS and Heckman selection models. The result from the regression analysis indicate that the most significant and consistent indicators of performance are GPA prior to taking the class, prior economics knowledge and SAT score. Therefore, it was suggested that instructors should encourage but not mandate attendance in both small and large lecture settings. Also, reports from Berenson *et al.* (1992), Hyde and Flournoy (1986) indicate that class attendance is not strong alone to affect student academic performance.

From the overall review, it was observed that most of the analyses done were based on statistical analysis which was able to give the data description rather than extracting hidden knowledge from the dataset which can give more insight into different patterns of the dataset. The statistical analysis was able to indicate whether good attendance implies good performance or vice versa but not able to give the extent of the impact in quantitative terms, so as to determine the proper minimum percentage attendance for courses. In this study, taking the advantage of the concept of data mining which has ability to extract hidden, previously unknown useful patterns an attempt is made to fill the identified gap by using a data mining technique which is able to identify hidden pattern of relationships between attributes in a dataset (Han and Kamber, 2001). Our approach is also able to determine in quantitative terms, the extent of the impact of one attribute on the other within a dataset using a measure of support and confidence.

RESULTS AND DISCUSSION

Dataset: A total of 752 student's records were investigated to analyse the impact of class attendance on student academic performance. The student academic performance was determined by student's total result score in Continuous Assessment (CA) and the final examination. The CA is 30% and the final examination carries 70% which sum up to 100%. The sample courses considered were all from the curriculum of the Department of Computer Science of Covenant University, a private university in Nigeria. The students under investigation are students of computer science, they are characterised by 3 attributes as shown in Table 3. Five different courses were considered based on two factors which are class capacity and nature of course. These factors are considered relevant in order to extract unique patterns of knowledge that represents different types of courses in the computer science department at different levels of class capacity. Also, different sets of students taught by different course lecturers were taken into consideration. This is to allow for variety of student's characteristics to be investigated under different class conditions which might be influenced by the course lecturer. The class capacity are represented by three linguistic partitions of small, medium and large as represented on Table 4. The class capacity for each partition is quite relative to the peculiarity of the enrolment of student into the computer science programme of Covenant University that was used as the case study. The course under consideration were classified into three categories as shown on Table 4. For the database implementation and storage, sql server management studio express was used as the Database Management System (DBMS). The dataset was modelled as a relational data model.

The data mining process: The quantitative association rule mining apriori-algorithm was adopted for the analysis because of the quantitative nature of the dataset and the simplicity of the algorithm to be implemented. This was implemented using C# programming language in the Visual Studio environment. The snapshot of the association rule mining interface is shown in Fig. 1. During the mining process, the attendance attribute and total scores attribute values were partitioned into intervals using a standard grading scale that is used within the Nigeria University System (Table 5) as approved by the National Universities Commission (NUC). This is slightly closer to equal-depth partition method than other method of partitioning (Han and Kamber, 2001). Table 6 shows the data partitioning for both attendance evaluation score and result score.

For the data mining process, fuzzy association rule mining was not considered because of the peculiarity of the data analysis domain and the process. The attendance

Table 3: Data description

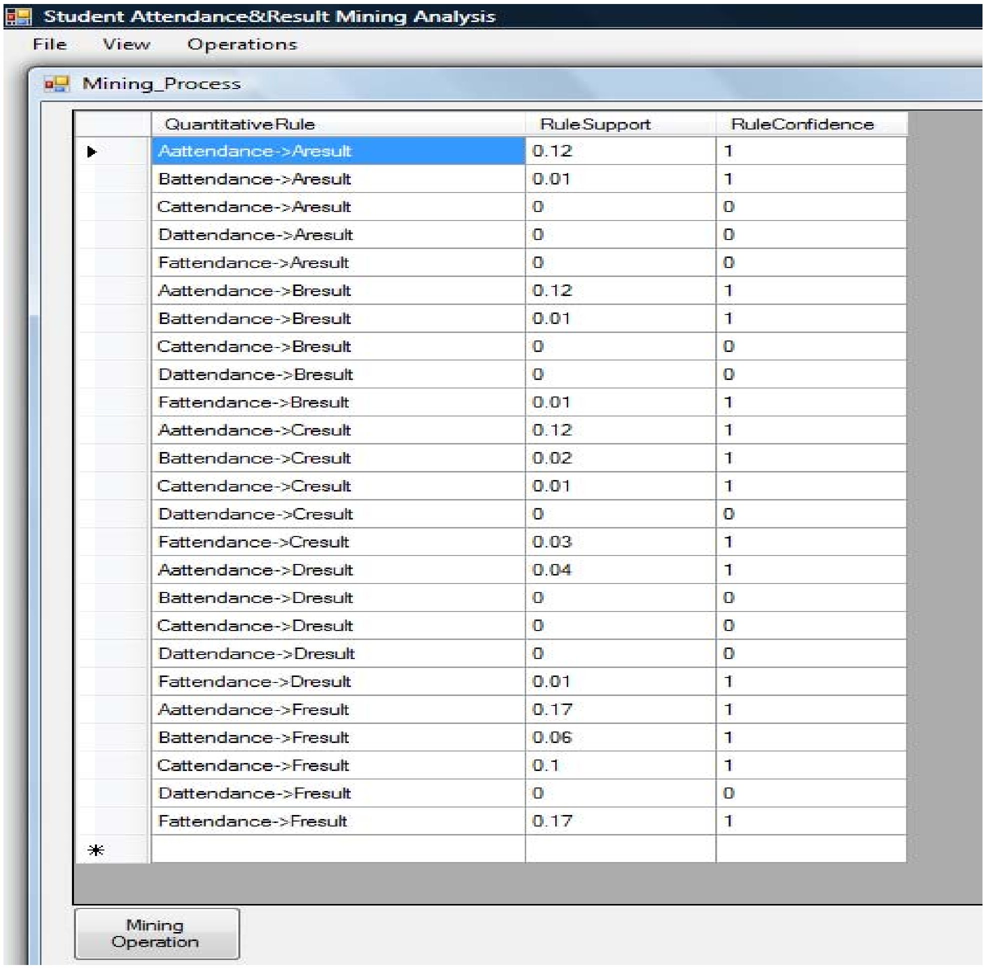
Attribute	Data description
Matric No.	Alphanumeric
Attendance	Numeric
Total score	Numeric

Table 4: Class capacity description

Linguistic partition	Class capacity
Small (X)	$X \leq 50$
Medium (X)	$50 < X \leq 100$
Large (X)	$X > 100$

Table 5: Course description

Course category	Course title/Code	No. of student	Class capacity
Mathematics-oriented	Numerical computation (CSC 432)	92	Medium
	Operation research (CSC 319)	267	Large
Programming	Java Programming (CSC 313)	135	Large
Science of computation	Theory of computing	68	Medium
Intelligence systems	Decision support systems (MIS 221)	74	Medium
	Fuzzy logic (CSC 418)	116	Large



QuantitativeRule	RuleSupport	RuleConfidence
Aattendance->Aresult	0.12	1
Battendance->Aresult	0.01	1
Cattendance->Aresult	0	0
Dattendance->Aresult	0	0
Fattendance->Aresult	0	0
Aattendance->Bresult	0.12	1
Battendance->Bresult	0.01	1
Cattendance->Bresult	0	0
Dattendance->Bresult	0	0
Fattendance->Bresult	0.01	1
Aattendance->Cresult	0.12	1
Battendance->Cresult	0.02	1
Cattendance->Cresult	0.01	1
Dattendance->Cresult	0	0
Fattendance->Cresult	0.03	1
Aattendance->Dresult	0.04	1
Battendance->Dresult	0	0
Cattendance->Dresult	0	0
Dattendance->Dresult	0	0
Fattendance->Dresult	0.01	1
Aattendance->Fresult	0.17	1
Battendance->Fresult	0.06	1
Cattendance->Fresult	0.1	1
Dattendance->Fresult	0	0
Fattendance->Fresult	0.17	1

Fig. 1: Snapshot for the mining process

Table 6: Attribute value partitioning

Attribute values	Range
70-100	A
60 -69	B
50-59	C
45-49	D
<45	F

value attribute is represented as either a student is present or absent (1 or 0) from the class. A student presence cannot be partial which makes the attendance score not subjective. Also, the student's result grades were considered and not the actual score which implies that a student's score can only belong to a particular grade category, hence, no overlapping of boundaries. Therefore, quantitative attributes were replaced with several boolean attributes according to the partitioning so as to formulate the problem as an instance of boolean association rules problem model. The dataset was then mapped into binary values such that the boolean value corresponding to <attribute1, value1>) would be 1 if the value1 in the original database falls under attribute1 partition range and 0 otherwise. Then binary association rule mining algorithm was used to discover association rules. Figure 2 shows the snapshot of the Boolean representation of the original relational dataset which was implemented by using C# programming language. To calculate the vote for each boolean attribute we used the multiplication operator (Π) so as to take into consideration all the attribute values in determining the attribute vote (Au and Chan, 1998).

The interesting measures of support and confidence were used to determine the significance of the generated rules and the confidence, these measures were derived based on Eq. 1 and 2, respectively (Srikant and Agrawal, 1996). We did the analysis on a course by course basis to determine the impact of percentage of student's attendance on their academic performance in different courses. The minimum support and confidence were set to zero, so as to harvest all possible patterns. The rules

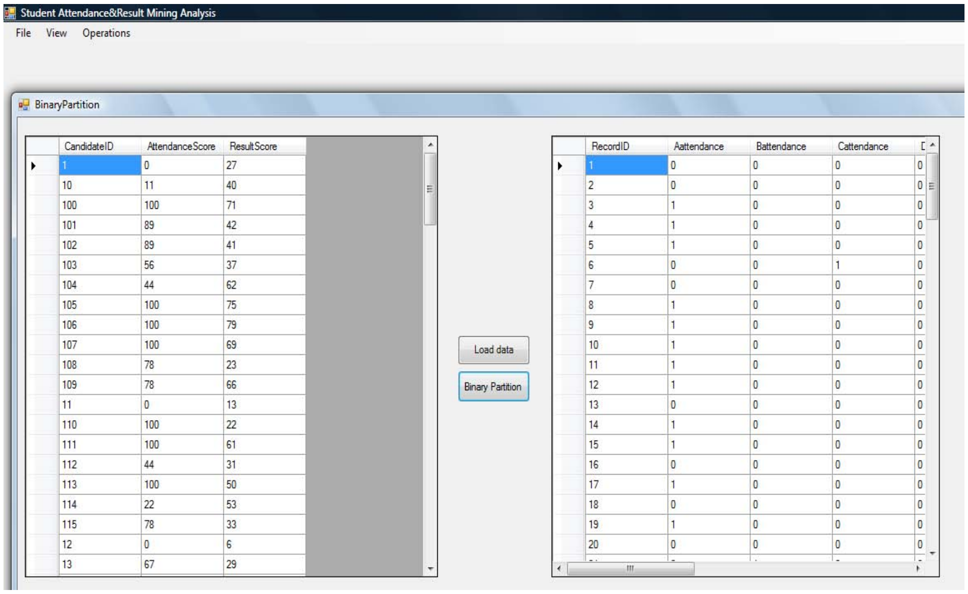


Fig. 2: Snapshot for boolean representation for sample data set

a course. The support value of such a rule indicates the percentage of the students that fall into that category within the entire class capacity. Also, the confidence percentage value interprets the percentage of student that still made "A" grade (Distinction) in a particular course among those with 70-100 attendance value.

Analysis results and discussion: The result of the data analysis revealed that most of the students under investigation had above 70 (>70) attendance score in all the courses considered. This shows the influence of the institutional policy on class attendance on the students. In the institution used for this case study Covenant University, if a student does not have up to 75% attendance score in a particular course, the student is not allowed to seat for the examination of that course. The only the exemption is if the reasons for obtaining a <75% score is health-related or some exceptional circumstances that are condonable based on the University's policy on student attendance.

Based on the association rule mining analysis carried out, five samples of the rules generated from the mathematics-oriented courses dataset are represented in Table 7. The rules are with antecedent "A_{Att}" (70-100% attendance score) which contain 92 and 86.2% of the class capacity from operation research and numerical computation courses, respectively. From the f5 rules it was observed that student's performance is spread across all the grades (A-D) for both the large classes and medium classes. This result implies that notwithstanding a

Table 7: Sample of the rules generated from the mathematics-oriented dataset samples

Rule No.	Rules	Support: Operation Research (OR)	Support: Numerical Computation (NC)
1	$A_{Att}\rightarrow A_{Result}$	0.06	0.36
2	$A_{Att}\rightarrow B_{Result}$	0.11	0.32
3	$A_{Att}\rightarrow C_{Result}$	0.25	0.17
4	$A_{Att}\rightarrow D_{Result}$	0.19	0.10
5	$A_{Att}\rightarrow F_{Result}$	0.31	0.02

Table 8: Sample of the rules generated from the intelligence systems samples

Rule No.	Rules	Support (Fuzzy logic)	Support (decision Support system)
1	$A_{Att}\rightarrow A_{Result}$	0.12	0.17
2	$A_{Att}\rightarrow B_{Result}$	0.12	0.28
3	$A_{Att}\rightarrow C_{Result}$	0.12	0.24
4	$A_{Att}\rightarrow D_{Result}$	0.04	0.07
5	$A_{Att}\rightarrow F_{Result}$	0.17	0.20
6	$A_{Att}\rightarrow A_{Result}$	0.00	0.01
7	$A_{Att}\rightarrow B_{Result}$	0.01	0.01
8	$A_{Att}\rightarrow C_{Result}$	0.03	0
9	$A_{Att}\rightarrow D_{Result}$	0.01	0
10	$A_{Att}\rightarrow F_{Result}$	0.17	0

student's consistent presence in the class such a student can still score mark that falls in any of the grade categories. Column 3, of Table 8 shows that just 6% of the students for Operation Research had >70 attendance score and "A" grade; 11% of the students had grade "B"; 25% had a "C", 19% had a "D" and 31% had an "F". The relationship between attendance scores and course grades of students is shown in Fig. 3. For the Numerical Computation course with a medium class capacity, the result is better in favour of student with "A" grade (36%). This shows that with fewer students when the class size

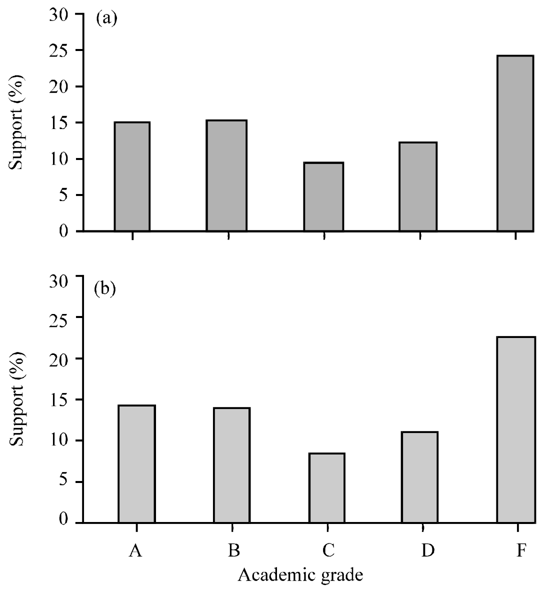


Fig. 3: Grade (%) of students with 70-100% attendance for fuzzy logic and DSS NC

Table 9: Sample of the rules generated from programming and machine computation courses

Rule No.	Rules	Support (Java programming language)	Support (theory of computing)
1	$A_{Att}\rightarrow A_{Result}$	0.27	0.15
2	$A_{Att}\rightarrow B_{Result}$	0.19	0.15
3	$A_{Att}\rightarrow C_{Result}$	0.22	0.09
4	$A_{Att}\rightarrow D_{Result}$	0.1	0.12
5	$A_{Att}\rightarrow F_{Result}$	0.11	0.24

is not so large, the lecturer in charge can actually monitor the student's participation in class apart from the fact that they are physically present in order to enhance their academic performance.

The selected rule samples from the courses fuzzy logic and Decision Support Systems (DSS) which belong to the intelligence systems category) are shown in Table 8. It is revealed that with a non-mathematics course a student can also obtain any grade, regardless of the attendance score. The rule support from Rule 5 on Table 9 entire students had >70% attendance and a score of <45 in the Intelligence Systems courses which means failed. Also from Rule 10, 17% of the student that were consistently absent in the class but permitted to do examination based on pardonable reasons still ended up scoring "F" grade in fuzzy logic. This shows that no matter how, absence in the class will limit good performance. Figure 4 shows the percentage grade of students with 70-100% attendance for Fuzzy logic and DSS.

Lastly, for the programming language (Java) course with a large class, the result is also well spread across all the grades, the same was also observed for the course

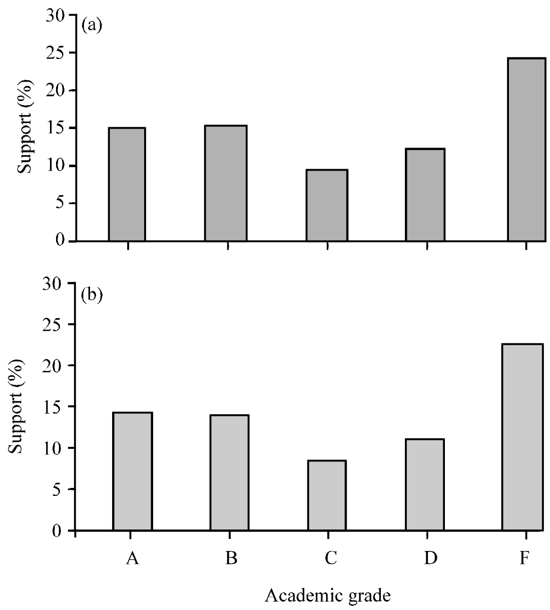


Fig. 4: Grade (%) of students with 70-100% attendance for Java and theory of computing

that pertain to the science of computation (theory of computing) with a medium class capacity. For the Java class, the lecturer was also able to manage the high percentage of attendance by students which is responsible for the higher percentage of "A" grade. This is very possible because of the practical nature of the course, whereby every student is made to participate in the class as long as the student is present. Unlike the theory of computing course, not with standing the capacity of the class, a higher percentage of the student still had "F". This is also not surprising because of the abstract nature of the course. If a student does not take time out to study the examples and try to solve some of the exercises on different types of primitive models of computations that have been taught outside the class, a student might not be able to attempt the questions in the examination. Hence, other factors apart from a student being present in class is crucial. In order words, factors such as active participation in class, engagements with assignment and exercises outside of the class and personal study determine good performance.

CONCLUSION

In conclusion, based on the analysis that was carried out on the impact of student class attendance and academic performance using association rule mining apriori algorithm in this study, we discovered that the impact of class attendance on academic performance is very low. A student with >70 % attendance score, can still fall into any grade between "A-F". This indicates that class attendance is not actually the factor that determines student academic performance but other key factors such as the student participation in the class, personal study and group study and so on. The advantage of good percentage of attendance score can be more visible if the class size is small such that the lecturer in-charge is able to monitor the student participation in the class. This will surely enhance the student academic performance. Also in case of abstract courses in addition to small class capacity, the student personal study is another factor that must be encouraged, so as to ensure good performance. Therefore, if good attendance records will be mandatory to qualify a student to sit for an examination, then the minimum attendance score should not be as high as 70%. Nevertheless, we may suggest, based on the experimental result of this study that any student with <60% should not be allowed to sit for examination. This is because from the result of our study, no matter how, prolonged absence from the class cannot yield good performance. Also, it is observed that there is more to class participation than physical appearance in class. In future study, we shall consider the additional factors apart from class attendance that can aid or hinder student's academic performance in order to also quantify the magnitude of their influence on student academic performance.

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