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A Fuzzy-Mining Predictive Model for Analysing Student's Academic Performance

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Abstract: In recent years, serious concerns have been expressed about the alarming rate of weak academic performance of students. A number of factors have been attributed to this trend. To this effect, this study analyzed the syndicate effect of some socio-economic factors: student's interest, relationship status, entrepreneurial activities, peer influence, health and family background on academic performance. Fuzzy mining approach was used to capture interesting patterns about the socio-economic factors and the student academic performance. Questionnaire approach was used to harvest student's level of involvement in the listed factors in quantitative measure. The questionnaire represented the student's opinions from 2 public and 2 private universities in Nigeria. The involved students are from 200 level and above, so as to accommodate for experience in the university system. Fuzzy association rule mining algorithm with triangular membership function was used for the mining process and fuzzy models. The result shows various hidden previously unknown patterns of student's involvement and the effect on their academic performance. This study interprets the patterns according to their inference as regards student academic performance. This, we hope will help institutions to monitor the student's academic performances with regard to these socio-economic factors and also serve as an indicator of measure for the students.

Key words: Academic performance, socio-economic factors, fuzzy association rule mining algorithm, fuzzy model, data mining, triangular membership function

INTRODUCTION

Student's academic performance has been defined as the outcome of education and the degree to which a student has attained the objectives of his or her institution (Agarana and Ehigbochie, 2015). The current policy of education in Nigeria emphasizes the important contribution of education to human and economic development. Students are the most significant asset of a university (Othman *et al*., 2013) and the culture and standard of universities could be weakened by student's academic performance. The relevance of student's academic performance, therefore, cannot be overemphasized as good academic performance of students produces good outcomes that could improve student's value, exempt students from criminal activities, open the students to huge opportunities, reduce menace in the society and give the students better self-esteem in the society. To this effect, it becomes a priority for every child and parent mind to give all it takes for good education while they are ignorant of some socio-economic factors which can adversely affect student's academic performance.

In the literature, a lot of analyses have been carried out on how different factors affect student's academic performance. These include some socio-economic factors (Bayat *et al*., 2014; Olayiwola *et al*., 2011). Socio-economic factors were observed to be major challenges confronting families, teachers, students and institutional managers every day which have resulted to weak academic performance (Considine and Zappala, 2015). Socio-economic factors can be described as a family or individual ranking on a hierarchy according to the access or control one has over some combination of valued commodities such as wealth, power and social status. Also, from a social point of view it is described as high quality work force with equal opportunity, social development of civil awareness and community attainment (Tomul and Polat, 2013). Economically, it is seen as innovation and the ability to increase the country's economic power. In socio-economic status of a student was described as the factor that determines the school a student attends, influences the chances of being accepted in the university and the potential income earning in life (Erdem *et al*., 2007). It is also described as the conceptualized social standing or class of an individual or group which is measured in a combination of income, education and occupation.

The student Cumulative Grade Point Average (CGPA) is the accepted academic performance indicator for students in higher institutions of learning. It is used to evaluate and validate the standard of student's

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performance and the level of progress students are making at the different level of progression in the university (Oyelade *et al*., 2010). It also tells if a student is in good standing or not. This is usually measured by examinations or constant evaluation processes in form of tests and assignments. Due to different factors, some students struggle to attain and maintain a high CGPA which aggregately transforms to a weak academic performance. The concern here is that these factors can adversely affect the nation's educational standard and in turn affect the economic ratings of the society. To this effect there is need for a strong awareness of such factors in order to weaken their effect on student's academic performance.

It was submitted that socio-economic backgrounds of the students and parents contribute significantly to the student's academic performance (Bayat *et al*., 2014). Also, the link between affluence and education can partially be the reason the poor receive inferior quality of education in comparison with their wealthier counterparts. A different opinion was presented: participants with middle/high socioeconomic status had significantly lower performance in comparison with those with lower socio-economic status in Iranian universities (Spaull, 2011). From another investigation by Tomul and Polat (2013), it was discovered that family income determines to a large extent how far the students could participate educationally because students attending the most successful universities in Taiwan are from the richest and most well educated homes. The importance of assignments, preschool education and availability of textbooks was also reported (Alos *et al*., 2015). In a study on factors influencing students academic aspirations in higher institution three main factors were identified. First was the social support which is vital to serving the basic needs for socialization as the transition to college or university is a time of vulnerability for a person's social network this could affect a student's attitude and behavior in the new environment. Second was the student's academic self concept which includes the conception of ability and worth that are influenced by general impression and comparisons. Third was the aspiration of the students which serves as the motivation for achievement. The submission is that a student academic performance can be predicted based on the student's family socio-economic status and his/her personal socio-economic level. Therefore, this study attempts to extract patterns from the syndicate effect of some family and personal socio-economic factors on student's academic performance using data mining approach. These patterns will enable students to monitor the impact of their socio-economic involvement on their academic performance. It will also function as a means by which an instituiton can supervise the performance of their students.

Literature review: In the literature, a lot of approaches have been introduced to analyze the effect of socio-economic factors on student's academic performance. The t-test analytical model was used to analyze student's academic performance based on parental income, family type, lack of funding, home background, learning environment, poverty and government policies. Okioga (2013) used a proportional sampling method to determine the impact of student's socio-economic background on academic performance in Kisii University, College. The study targeted both male and female students. It was reported that student's inability to afford good residential rooms, catering facilities and recreational facilities were based on their socio-economic status and this had adverse effect on their academic performance. In a case study of Islamic Azad University, it was discovered that gender, interest of students, employment status, type of diploma and family foundation before entering the university had significant effect on the student's academic performance (Kuok *et al*., 1998). Multiple regression and canonical analysis were used. It was observed that parent's financial status, hostel facilities, lecturer teaching method, available educational resources and peer group had a significant relationship with the student's academic performance (Olayiwola *et al*., 2011).

In a cross sectional survey on factors affecting student's academic performance at a Turkish University with 1717 participants, chi-squared independent test for analysis was used (Erdem, 2013). The study reported that there was no significant relationship with student's gender, city from which they come from and good communication with instructors on their academic performance. On the other hand, the class attendance, father's educational level, high school graduated from and preparatory school attendance were reported to have effect on student's academic performance. Among other observations in the study was that a unit increase in parental financial status brought about 10.28% increments in academic performance of the student and a unit improvement of the hostel facilities resulted to 2.63% increase in student's academic performance. Also, a unit increase in lecturer teaching methods brought about 4.01% increase in the academic performance of the students (Olayowola *et al*., 2011). However, even with these measures taken, lots of students have not been able to handle some challenges posed by their academic performance this has become a major issue

of concern to the management of institutions (Yazedjian *et al*., 2008; Basil and Yinusa, 2008; Michikyan *et al*., 2015).

From the various reviews of literature, most of the analysis on socio-economic factors were based on statistical analysis which might not be able to extract unknown, hidden and useful patterns from the data set. Also, most of the factors were considered independently not minding the levels of socio economic status. Hence, the need for a predictive model to determine the syndicate effect of some socio-economic factors on student's academic performance at different levels of involvement. In this study, some socio-economic factors are captured to determine their syndicate effect student's academic performance. The factors are; student's interest in the course of study, marital relationship status, entrepreneurial activities, peer influence, health condition and family background. This study aims to enhance growth, willingness, motivation in the various levels of development of student's life, increase the momentum of students to study and create a platform that could help students prioritize and come up with informed decisions. It is also to enable the student make the right decision as touching their involvement in some factors that can affect their academics adversely.

The aim of this study is to build predictive models to help determine the syndicate effect of some socio-economic factors on student's academic performance. This will obviously reveal the various patterns on how different levels of socio-economic factors affect student's academic performance. The study will also show extracted hidden and useful patterns for students to assess their involvement in these factors. It will serve as a predictive model to student's advisors, faculty, staff and institutional managers in tracking or monitoring the academic performance of students and also enhance student's decision on their involvement on socioeconomic factors. To realize this from previous research, fuzzy association rule mining technique has proven to be effective in discovering hidden, interesting and useful knowledge in educational database (Oladipupo *et al*., 2012).

MATERIALS AND METHODS

Data source: The data source for this study is a random sample of 200 level students and above from some private and public universities in Nigeria. The sample comprises both males and females. This academic level rage is considered because it is assumed that they are no more new to the university system. The students provided required answer based on their experiences in the university about the factors. The 2635 copies of questionnaire were collected out of which 2535 were used which amounted to 96.2% the remaining 100 records were voided because of incompleteness and unrealistic nature of the data collected. This resulted to 3.8% of the dataset. The dataset consists of 2535 record with 7 attributes. The 6 of the attributes are input attributes (student interest, entrepreneurial involvement, peer influence, family background, peer influence, marital status and health condition) while the last one is the output attribute (CGPA). MYSQL XAMPP 1.7.7 was used as the Database Management System (DBMS) to store the student's records. A database was created called student-input, based on the database, 19 relations were created which were housed by the database.

Research instrument: The research instrument for data gathering was questionnaire approach. The information in the questionnaire was able to capture a student age, sex, CGPA, student interest, entrepreneurial involvement, peer influence, family background, marital status and health condition. The questionnaire was constructed by the researcher. The questionnaire items were formulated after a careful review of literatures. The questionnaire was made up of seven items covering various factors on socio-economic factors. Six of the attributes were input attributes and one output attribute (CGPA). For each attribute there are 5 questions which reflected the importance of each attribute.

The student's responses are in 5 categories: strongly agree, agree, undecided, disagree, strongly disagree. To assign a crisp value to each response a five point likert scale was used values were assigned according to how the question has impact on the factors as related to the research analysis. For instance, a positive impact question was assigned 10 points for strongly agreed and for negative impact questions 0 was assigned. This can be seen in Table 1. To get the crisp value for a particular attribute, aggregate sum was used to acquire quantitative values for each factor as shown in Eq. 1. A typical example is shown in Table 2:

$$A = \sum_{i=1}^{n} x_i \quad (1)$$

where, x_i represents each factor. For example for this particular student's response to interests in Table 2 the crips value is generated as shown in Table 3. Based on this response, aggregate sum was used to get the crisp value:

$$A = \sum_{i=1}^{n} x_i$$

$$A = 0+2+5+10+5 = 22$$

Table 1: Questionnaire attributes response value rating

Socio-econimic factor values	Values
Interest/response	
Strongly agree	0
Agree	2
Undecided	5
Disagree	8
Strongly disagree	10
Entrepreneurial involvement	
Strongly agree	10
Agree	8
Undecided	5
Disagree	2
Strongly disagree	0
Family background	
Strongly agree	10
Agree	8
Undecided	5
Disagree	2
Strongly disagree	0
Peer influence	
Strongly agree	0
Agree	2
Undecided	5
Disagree	8
Strongly disagree	10
Relationship	
Strongly agree	0
Agree	2
Undecided	5
Disagree	8
Strongly disagree	10
Health condition	
Strongly agree	0
Agree	2
Undecided	5
Disagree	8
Strongly disagree	10

Table 2: Aggregate sum of factors based on the interest of a student

Interest	SA 0	A 2	U 5	D 8	SD 10
I am interested in schooling or education in general	✓	-	-	-	-
I love my course	-	✓	-	-	-
I am active in class	-	-	✓	-	-
I love being in class	-	-	-	-	✓
I chose this course myself	-	-	✓	-	-

Table 3: Range partitioning for the attributes

Socio-econimic factor values	Linguistic terms
<25	Low
25-34	Average
35-50	Hogh
CGPA	
4.5≤G≤5	CGPA 1
3.5≤G≤4.5	CGPA 21
2.5≤G≤3.5	CGPA 22
1.5≤G≤2.5	CGPA 3

Therefore, 22 is the crisp interest value for this particular student. For each attribute, the maximum value is 50 and the minimum is 0. All input attributes values are partitions following the ranges in Table 3 and the output attribute values is partition as in Table 3.

Fuzzification process: For fuzzification process the input attributes and output variable fuzzy sets are determined as shown in Table 4. The fuzzy models for all the input attributes were based on the triangular membership function (trimf) because of the nature of the dataset. Since, all the input attributes follow the same partitions, therefore, their membership expressions also follow the same pattern. For instance the membership expression for student interest is represented in Eq. 2-4. For the output variable; 'CGPA' the membership expression is represented with a straight line (linear, y = mx+x) membership function. This is found appropriate because according to the standard Nigeria University Commission (NUC) CGPA grading of a student cannot overlap to another class of honour. To this effect the membership value for each candidate within their class of grade is determined. The membership expression is shown in Eq. 5-8 from 21, 22, 3rd class and pass, respectively:

Table 4: Fuzzification of linguistic variables

Linguistic variables	Fuzzy sets
Interest	{intlow, intAve, intHigh}
Entrepreneural involvement	{entlow, entAve, entHigh}
Family background	{fblow, fbAve, fbHigh}
Peer influence	{pillow, piAve, piHigh}
Relationship	{rellow, relAve, relHigh}
Health condition	{hclow, hcAve, hcHigh}

$$\mu_{int}(\text{Low}) = \begin{cases} 1 & \text{if } x \le 20 \\ \dfrac{30-x}{10} & \text{if } 20 \le x \le 30 \end{cases} \quad (2)$$

$$\mu_{int}(\text{Ave}) = \begin{cases} \dfrac{x-20}{10} & \text{if } 20 \le x \le 30 \\ 1 & \text{if } 30 \le x \le 35 \\ \dfrac{45-x}{10} & \text{if } 35 \le x \le 45 \end{cases} \quad (3)$$

$$\mu_{int}(\text{High}) = \begin{cases} \dfrac{x-45}{10} & \text{if } 3 \le x \le 45 \\ 1 & \text{if } 45 \le x \le 50 \end{cases} \quad (4)$$

$$\mu_{GPA1}(g) = (2 \times g) - 9 \quad (5)$$

$$\mu_{GPA21}(g) = \frac{g}{0.99} - 3.54 \quad (6)$$

$$\mu_{GPA3}(g) = \frac{g}{0.99} - 1.52 \quad (7)$$

$$\mu_{GPA22}(g) = \frac{g}{0.99} - 2.53 \quad (8)$$

The membership models were implemented with Java programming language. The output from this process is a fuzzified dataset which serves as an input to the next stage of the process. A Java Nebeans 7.3 Snapshot of the fuzzification process module is shown in Fig. 1.

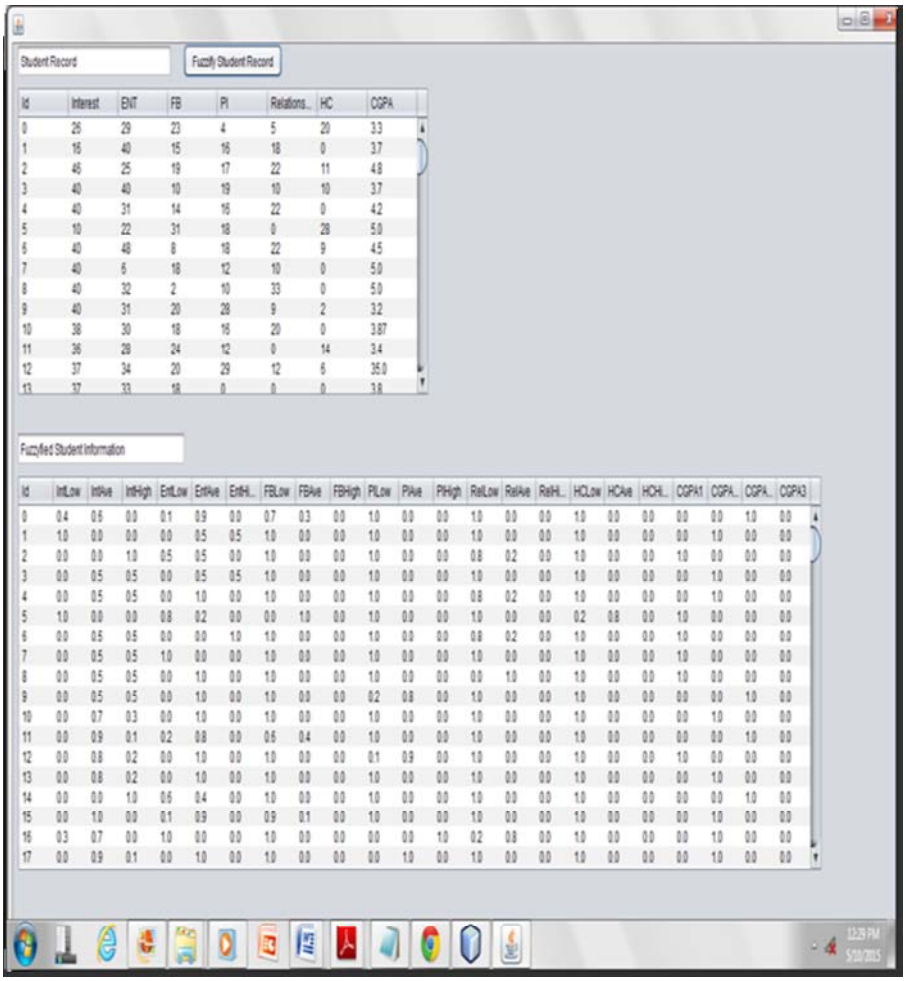

Fig. 1: Fuzzification process snapshot showing sample data and fuzzy equivalent

Mining process: For the mining process, Apriori-Like Fuzzy Association Rule Mining algorithm was adopted since the nature of the dataset to be analyzed was quantitative. The algorithm was implemented using Java programming language. This was adopted because it's peculiar features for implementing algorithms. It also enhances a user friendly interface. For a rule to be considered interesting it should have enough level of certainty and significance. To determine the significance and certainty value of a rule the following formulae were implemented along side with the mining algorithm:

$$\text{Significance} = \frac{\text{Sum of votes satisfying } \langle X, A\rangle}{\text{No. of records in D}} \quad (9)$$

$$FS_{\langle X, A\rangle} = \frac{\sum_{t_i \in D} \prod_{x_j \in X} d_{x_j}\left(a_j, t_i, x_j\right)}{|D|} \quad (10)$$

Where:

<X, A> = The fuzzy itemset pair

X = The sets of attributes x_j

A = The set of fuzzy sets a_j

And in calculating the certainty factor:

$$\text{Certain factor} = \frac{\text{Sum of votes satisfying } \langle Z, C\rangle}{\text{Sum of votes satisfying } \langle X, A\rangle} = \frac{\sum_{t_i \in D} \prod_{z_j \in Z} d_{z_j}\left(c_j, t_i, z_j\right)}{\left|\sum_{t_i \in D} \prod_{x_j \in X} d_{x_j}\left(a_j, t_i, x_j\right)\right|} \quad (11)$$

Where:

Z = X∪Y

C = A∪B

The outputs from the mining process are numbers of patterns in form of rules. The minimum significance factor

No. Of. Rules 2916

RecordNo	Rule	Significance	Confidence
0	intLow,entLow, fbLow,piLow,relLow,hcLow-->cgpa1	99.8	13.6
1	intAve,entLow, fbLow,piLow,relLow,hcLow-->cgpa1	99.7	13.5
2	intHigh,entLow, fbLow,piLow,relLow,hcLow-->cgpa1	99.8	13.5
3	intLow,entAve, fbLow,piLow,relLow,hcLow-->cgpa1	99.7	13.6
4	intAve,entAve, fbLow,piLow,relLow,hcLow-->cgpa1	99.7	13.5
5	intHigh,entAve, fbLow,piLow,relLow,hcLow-->cgpa1	99.7	13.4
6	intLow,entHigh, fbLow,piLow,relLow,hcLow-->cgpa1	99.9	13.5
7	intAve,entHigh, fbLow,piLow,relLow,hcLow-->cgpa1	99.9	13.5
8	intHigh,entHigh, fbLow,piLow,relLow,hcLow-->cgpa1	99.9	13.4
9	intLow,entLow, fbAve,piLow,relLow,hcLow-->cgpa1	99.5	13.6
10	intAve,entLow, fbAve,piLow,relLow,hcLow-->cgpa1	99.2	13.5
11	intHigh,entLow, fbAve,piLow,relLow,hcLow-->cgpa1	99.6	13.5
12	intLow,entAve, fbAve,piLow,relLow,hcLow-->cgpa1	99.5	13.6
13	intAve,entAve, fbAve,piLow,relLow,hcLow-->cgpa1	99.4	13.5
14	intHigh,entAve, fbAve,piLow,relLow,hcLow-->cgpa1	99.8	13.4
15	intLow,entHigh, fbAve,piLow,relLow,hcLow-->cgpa1	99.4	13.5
16	intAve,entHigh, fbAve,piLow,relLow,hcLow-->cgpa1	99.1	13.5
17	intHigh,entHigh, fbAve,piLow,relLow,hcLow-->cgpa1	99.5	13.4
18	intLow,entLow, fbHigh,piLow,relLow,hcLow-->cgpa1	99.2	13.6
19	intAve,entLow, fbHigh,piLow,relLow,hcLow-->cgpa1	99.0	13.5
20	intHigh,entLow, fbHigh,piLow,relLow,hcLow-->cgpa1	99.5	13.5

Fig. 2: Snapshort some interesting rules

and certainty factor threshold used is set 0.0, so as to capture all support rules for proper analysis. The implication is that if any rule does not have significant value and certainty value >0 such rule is not interesting for the analysis. A sample output snapshot is shown in Fig. 2 and Algorithm 1. Apriori-like Fuzzy Association Rule Mining Algorithm (Kuok *et al*., 1998).

Main algorithm (minsup, minconf, mibcorr, D):

I = Search (D);
(C_1, D_T) = Transform (D, I)
k = 1
(C_k, F_k) = Checking (C_k, D_T, minsup);
while ($|C_k| \neq \varnothing$) do
being
inc (k);
if k == 2 then
C_k = Join1 (C_{k-1});
else C_k = Join2 (C_{k-1});
C_K = Prune (C_k);
(C_k, F_k) = Cheaking (C_k, D_T, minsup);
F = F∪F_k;
end
Rules (F, minconf, mincorr)

RESULTS AND DISCUSSION

After the mining process, patterns were generated in form of rules which have significant interpretation in the context of the socio-economic effect on student's academic performance. For instance, Table 5 shows some interesting patterns from the mining process in the form of rules.

For a balanced level of a student's involvement in socio-economic activities, the entrepreneurial involvement of the student should be low, the peer influence of the student should be low and the relationship level of the student should be low; all these are to reduce distractions for the student so as to concentrate more on academics. The interest level of the student should be high, so as to enhance the student readiness for classes and reading. The health condition of the student should be high, so as to avoid stress. The family background of the student should be high that is the family financial buoyancy and how fast the student's needs are attended to. With these, a student has strong possibility to focus on his/her academic pursuit and come up with good grades.

From Table 3, the rule 1 shows a scenario where student's interest is low, entrepreneurial involvement is low, family background is low, peer influence is low, relationship background is low and health condition is low. The students in this category of population sample are confirmed with a significance factor of 99.7%. This shows that a higher number of the students considered are in this category. From this result, the obvious class of performance for this category of students is second class

Table 5: Some interesting rules

Rules	Significance (%)	Confidence (%)
intLow, entLow, fbLow, pilLow, relLow, hcLow¬CGPA1	99.7	13.6
intLow, entLow, fbLow, pilLow, relLow, hcLow¬CGPA21	99.7	37.6
intLow, entLow, fbLow, pilLow, relLow, hcLow¬CGPA22	99.7	41.5
intLow, entLow, fbLow, pilLow, relLow, hcLow¬CGPA3	99.7	7.3
intLow, entHigh, fbhigh,pihigh, relhigh, hchigh¬CGPA1	25.7	13.7
intLow, entHigh, fbhigh,pihigh, relhigh, hchigh¬CGPA21	25.7	39.6
intLow, entHigh, fbhigh,pihigh, relhigh, hchigh¬CGPA22	25.7	37.1
intLow, entHigh, fbhigh,pihigh, relhigh, hchigh¬CGPA3	25.7	9.6
intLow, entHigh, fbAve, piAve, relAve, hcHigh¬CGPA1	60.8	10.8
intLow, entHigh, fbAve, piAve, relAve, hcHigh¬CGPA21	60.8	37.2
intLow, entHigh, fbAve, piAve, relAve, hcHigh¬CGPA22	60.8	37.4
intLow, entHigh, fbAve, piAve, relAve, hcHigh¬CGPA3	60.8	8.5
intHigh, entHigh, fbhigh,pihigh, relhigh,hchigh¬CGPA1	46.4	10.6
intHigh, entHigh, fbhigh,pihigh, relhigh,hchigh¬CGPA21	46.4	38.8
intHigh, entHigh, fbhigh,pihigh, relhigh, hchigh¬CGPA22	46.4	44.3
intHigh, entHigh, fbhigh, pihigh, relhigh, hchigh¬CGPA3	25.7	9.1

lower which is supported with 41.5% certainty factor, followed by second class upper with certainty factor of 37.6%. This positive grade is influenced by the student's ability to minimize distractions. Though, the student interest is low, family background is low and the health condition is not very strong to withstand stress but the student was able to do away with involvement in some essential factors. Such as entrepreneurial activities, negative peer influence and un-necessary relationship that can distract. From the rule, this category of students might not fall into first class and at the same time hardy can they fall into third class.

Another, interesting condition is found in rule 2 where only the interest is low while other factors are high. These students show three disadvantaged factor values the interest, entrepreneur involvement and relationship involvement with two advantaged factor values of family background and health condition. The peer influence shows the reasons why the student is involved in so many things beside the academics. From the rule, students in this category are just 25.7% of the population samples. The obvious class of performance for this student is second class upper with 39.6% certainty factor this is likely influenced by the family buoyancy and student strong ability to withstand academic stress. But in a situation whereby the student's heath fails he may end up with second class lower with certainty value of 37.1%.

CONCLUSION

This research has been able to come up with a predictive model for determining the effect of socio-economic factors on student academic performance. Fuzzy models for six socio-economic factors were built and their group effect was analyzed on how it affects student's academic performance. Fuzzy-Apriori algorithm was used for mining to discover interesting patterns that could monitor student's involvement in some socio- economic factors which were stored in a knowledge base from which fired rules match for the input. If the proposed model is adopted, it will increase student's awareness on the effect of socio-economic factors it will also help balance the student's involvement in socio-economic activities. Also, it will serve as a model for institutions to monitor student's academic performance in regard to socio-economic factors and enhance student's decision on socio-economic factors.

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