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Implementing knowledge discovery in enhancing university student services portfolio management in higher education institutions

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Abstract

Aim: The Student Welfare and Formation Office (SWAFO) of De La Salle University-Dasmarinas, Philippines, used Classification Techniques and Data Envelopment Analysis to analyze student demographics and disciplinary infractions. This paper describes how Knowledge Discovery was used to improve the management of the university's portfolio of student services.
Methodology: To identify the effective Decision-Making Unit (DMU) attributed to colleges, the Data Envelopment Analysis was used. The correlation between student demographics and offending behavior was analyzed using the CHAID algorithm.
Findings: The CHAID algorithm is implemented in a software application that is designed to be a predictive analytical software application that predicts student offenses, and a remediation plan is developed as a result. The SWAFO staff and five (5) IT professionals evaluate the software.
Implications/Novelty: This research will help SWAFO's process improvement initiative and delve deeper into the change by utilizing the remediation system plan. This work adds to our understanding of DEA and the design of remediation systems in higher education.

Keywords: Data Mining, Classification, Decision Tree, CHAID Algorithm, Data Envelopment Analysis

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INTRODUCTION

Higher education institutions provide various services to their students from application to graduation, with the student serving as the institution's primary consumer (HEI). Every step of a student's university career, from admission to graduation, is managed according to the policies and guidelines reflected in the university's Student Handbook, reflecting the university's approach to maximizing each student's potential. Every student is responsible for reading the Student Handbook, which was made available by the Office of Student Services and contains important information and guidelines about the university, its campus resources, life within the university, and the policies and guides for every student's academic success. The SWAFO is accountable for enforcing the Student Handbook's disciplinary guidelines. Goals include guiding and supervising students to become God-fearing, patriotic, and, above all, disciplined and excellent professionals in the future, as well as sharing the rounded formation of students for a decent and godly life in words, deeds, relationship with the community, and environment. Every university keeps a tally of how many students have been suspended or expelled for various infractions. With an average student body of 12,400 in 201213, the 55.81 percent of students in violation amounts to 6,921. There were an average of 12,755 students in the 201314 school year, and 5,236 had a violation. This corresponds to a violation rate of 41.05 percent. There were an estimated 13,361 students in the 2014-2015 school year.

Of these, 6,071 (or 45.44%) violated school policy. Based on the above mentioned data, knowledge Discovery will be used to analyze demographics and student offenses using Data Envelopment Analysis (DEA) and Classification Techniques at De La Salle University-Dasmarias, Philippines.

As a result, the seven (7) universities and the SWAFO will use the study to aid in reducing minor and major offenses. This research may prove useful in advancing SWAFO's initiative to improve its processes and delve

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deeper into the implications of its remediation system plan. It is possible that the findings of this study could be used to provide decision and policymakers with statistically sound information upon which to base their decisions and from which they could derive some policy implications. As an added bonus, the research may add to our understanding of DEA and the design of university remediation systems. The findings could also benefit similar fields in mathematics, computer science, and soft computing.

LITERATURE REVIEW

DEA as amongst the data mining techniques has been advocated by Charnes et al. (1997). DEA has long been used as a technique in conducting analysis and efficiency evaluation in the banking industry, educational institutions, farming and agriculture, crimes, among all others.

Brettenny and Sharp (2016) examined the efficiency of water services in rural and urban areas of South Africa. The results of the study performed adequately in relative technical efficiencies (Owusu 2016). Ibrahim and Salau (2016) used the DEA in a study conducted at North Central Nigeria to measure the technical efficiency of village extension agents and to increase farm productivity. The result implication was based at the village level that in order to improve the agricultural activities and extension undertakings, compensation of the agents must be paid and provided promptly. Ya, Escalante, and Xiaofei (2016) utilized the DEA techniques to estimate the efficiency scores to measure the prioritization schemes of Chinese and Indian Micro Finance Institutions (MFIs) that operate at different levels of maturity. The results of the study using a single-output efficiency analysis showed that more mature Indian MFIs obtained a greater efficiency than the younger Chinese MFIs when social outreach goal was prioritized. Hunjet, Neralić, and Wendell (2015) have employed data envelopment analysis in their study for the 12 selected towns in Croatia.

The study analyzed the computational results by measuring the dynamic relative efficiency. Also, Bi-Huei, and Shin-Bin (2015) contribution focused on the efficiency of ERP in the business performances of 25 Taiwanese IC companies considering the pre and post ERP installation. Based on the study, there had been a significant efficiency improvement manifested. Jandaghi (2015) and Liu and Dong (2016) measured and compared the research group in terms of efficiency in the Center for Social and Cultural Research. The rate of output is evaluated by input to determine effective and non-effective units. Narimatsu et al. (2015) evaluated the usefulness of risk models and used DEA to predict obesity by calculating efficiency scores. This work illustrated that it was possible that DEA can complement and help in predicting environmentally-driven obesity, so as to establish a well-fitted model for the risk of obesity. It was also reported that all indicated factors were attributed to being statistically significant. Toloo, Barat, and Masoumzadeh (2015) and Due (2016) research focus was on considering selective measures by identifying some inputs and outputs and devise an acceptable result whenever the performance measure is likely and relatively large compared with the other Decision-making units. The model was modified to achieve a model which could be used in order to select inputs and outputs to measure the performance of the DMUs.

Hong (2014) utilized the two-step DEA methods to measure the relative efficiency of 48 orchestras who joined in the projects of the League of American Orchestras year 2009 to 2010 to identify the fundraising activities as well as the delivery of the services. Chaloob, Ramli, and Nawawi (2014) utilized a nonparametric tool to identify solutions that maximize net benefit making of farmers to have a maximum use of control resources in Iraq using DEA. Wu et al. (2013) improved the dependent DEA model to establish and develop a ranking system for the nations and regions that were participating in the sports. The results were beneficial in the future directions of sports management strategic initiatives for the Asian nations. Kazan and Baydar (2013) used DEA as a performance measurement tool to help the decision makers in making the right decision. It measured the bank's productivity and efficiency. The results of the study exhibited that 13 banks were active, productive, and efficient, while 8 of the banks were below efficiency limit and active institutions analyze the data obtained from the CCR data-oriented and improvement tables were prepared for inactive banks.

Shen et al. (2012) compared different countries in terms of road safety performance. Three DEA models are considered which are the DEA-based road safety models, the cross-efficiency method, and the categorical DEA model. The work of Shen et al. (2012) and the other researchers showed the evaluation of the average road safety efficiency of those 27 European countries as well as the ranks by country. Wu (2012) conducted

the efficiency assessment and ranking using the super-efficiency DEA model including the gray entropy scoring method. DEA model has long been recognized as one of the methods and popular ways to identify and recognize the best performer. On the clearer note, the super-efficiency model is commonly and has suitably been used among several DEA models because it enables an organization or a unit to attain an efficiency score which is greater than 100%. Rouse, Harrison, and Li (2010) discussed a formal method of performance measurement, which is Data Envelopment Analysis and its application in Australasia. DEA is useful in providing rankings, targets, and identifying best practices but the application of the method still requires managerial judgment around specifications of the model, interpretation of the results, and identifying actions to improve performance (Nuchso et al. 2016).

The decision tree is widely used to create a classification model. Several scholarly works were identified using a classification data mining technique. Abdar et al. (2016) studied on the liver disease through using two well-known methods in data mining area. Dataset was analyzed by two algorithms named Boosted C5.0 and CHAID algorithms. The result showed that in both algorithms, DB, ALB, SGPT, TB, and A/G factors have a significant impact on predicting liver disease. Farid et al. (2016) utilized classification data mining using decision tree algorithm in Mellat Bank in Shira for the customer relationship management system. The decision tree model includes ID3, C4.5, and CART applied for classifying and used for prediction. Madhusudana et al. (2016) presented a classification of healthy and faulty conditions of the face milling tool using the Naive Bayes technique for the monitoring system. The results attained that the Naive Bayes technique recommended for online monitoring and fault diagnosis of the face milling tool. Jimenez-Perez and Mora-Lopez (2016) applied and utilized two data mining techniques using clustering and classification techniques for determining the global radiation for the next day with hourly prediction values. Results showed that it was based on per chance that the hourly solar radiation values prediction can be done using the clustering and classification to the next day's predicted values.

Esteban et al. (2016) developed and validated a Classification and Regression Tree (CART) to predict short-term mortality among patients evaluated in an emergency department for an eCOPD. The lowest mortality rate was for the branch composed of low baseline dyspnea and absence of cardiac disease. The utmost mortality rate was in the branch of the top baseline dyspnea level, use of paradoxical breathing upon arrival in Emergency Department, and Glasgow score < 15. Song and Ying (2015) focused on a decision tree methodology for a data mining technique in a classification system based on multiple ranges of prediction algorithm for a specific variable. The study discussed the most common algorithms used to develop decision trees such as CART, C4.5, CHAID, and QUEST and depicted the SPSS programs and SAS programs that are used to envision the tree structure. Kotsiantis (2014) endeavor an increase in the prediction precision of a decision tree model by incorporating local application of Naïve Bayes classifier. The study executed into a large-scale comparison with advanced algorithms of 30 standard benchmark datasets. The proposed method using the decision tree gave statistically superior precision in some cases. The work of Barbosa et al. (2014) employed the Naïve Bayes and Decision trees for classifying battery eggs and free-range eggs. With these machine learning algorithms, it was determined that based on the samples with the mineral contents, there were 80% of high-level precisions of free-range and 90% of battery eggs. This further was used in another way for adulteration calculation of free-range eggs.

Bisoi, Dash, and Nayak (2014) presented a novel contribution to power signal disturbance detections as well as classifications that constitute a relevant piece of power quality assessment. The extracted features were handed and the disturbance patterns were determined using the decision tree-based classifier. Barros et al. (2013) investigated an automatic design with empirical analysis using the hyper-heuristic evolutionary algorithm that was able to have an automatic design for top-down decision-tree induction algorithms. Based on their analysis, it was postulated that the hyper-heuristic evolutionary algorithms for decision-tree were proficient in generating algorithms and were extensively more accurate than C4.5 and CART. Abellan and Masegosa (2012) worked on the cost-sensitive problem using the precise classifier for the imprecise classification. This methodology is a new and novel way to evaluate the performance of an imprecise classifier. The decision tree was constructed to tailor the imprecise classification for the imprecise classifier. It used the Imprecise Dirichlet Model (IDM) for the representation of data and evidence in the form of information using the upper entropy for splitting.

The DEA-related literature is similar to the research study in measuring the relative efficiency of the organizations. The research study used an input-oriented orientation of DEA model using the radial measure of

efficiency while the other related literature used other DEA orientations. The research study was also verified using other DEA models such as a non-radial measure of efficiency and hybrid model to assess and evaluate the efficiency of the organizations.

Both the related literature and the research study used data mining technique of classification decision tree for extracting pattern. The related literature was limited to generating patterns and efficiency measurement of the organizations was not included in the study.

All DEA literature was used to measure the efficiency of the organization while data mining literature was used to extract pattern using a classificatison data mining technique. The novelty of the study is that the research study used the concept of data envelopment analysis and data mining to combine both existing fields into one.

The research study used the measurement efficiency of seven (7) colleges in terms of reducing student violations using data envelopment analysis and extracting the dataset of the inept colleges to enhance the efficiency in terms of reducing violations using data mining technique of classification CHAID decision tree.

METHODOLOGY

Research Design

DEA is a method used for measuring the efficiency of a certain number of units referred to as decision-making units, commonly known as DMUs. DEA measures the efficiency of the DMUs using the formula presented below:

$$\text{Performance} = \frac{\text{virtual output}}{\text{virtual input}} = \frac{u_1 y_{1o} + \ldots + u_s y_{so}}{v_1 x_{1o} + \ldots + v_m x_{mo}} \tag{1}$$

where:
x and y are resp. the input and output vectors and
u_s output$_s$'s weight, v_m output$_{m's}$ weight.

DEA was used to measure the efficiency of seven (7) colleges in the institution to determine which the efficient college is.

CHAID algorithm will be used to determine the relationship between the demographic profile of the students and the category of offenses. Also, Cross Tabulation is a tool used to analyze categorical data and present the multivariate frequency distribution of the variables. A remediation plan will be developed as an implementation of CHAID algorithm in a software application. The software application will be evaluated by the personnel of SWAFO and five (5) IT Experts using ISO 25010:2011 standards. The results will be interpreted using weighted mean and standard deviation.

The proponent of the study gathered the data through interview, Library method of research, and Secondary Data analyses on minor and major offenses from three (3) years' data of School Years 2012-2015. The proponent interviewed the personnel of the SWAFO unit to validate the research study. The proponent also used library research to gather additional information that supports the research study through the use of books, journals, articles, magazines, online publications, unpublished theses, and dissertations. The proponent adopted the software criteria from ISO 25010:2011 in formulating questionnaire as a tool to evaluate the software quality.

A statistical tool for data analysis that was used is weighted mean and sample standard deviation.

Statistical Package for the Social Sciences (SPSS) will be used to generate the model using decision tree CHAID algorithm.

Software Development Life Cycle

The researchers have used employ the rapid application development model in developing the software applications.

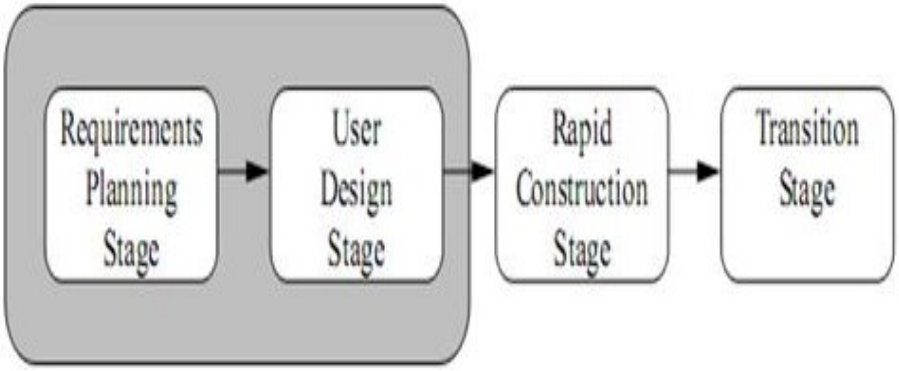

Figure 1. Rapid application development model

The application development model employed by the researcher is the Rapid Application Development (RAD). This model illustrates a descriptive and disciplined approach to software development. The RAD model is process-centric which implies that less emphasis on the planning was undertaken.

Phases of rapid application development

Requirement / Planning state

The requirement planning specifies a necessary technical requirement, data requirements, including the functional and non-functional requirement of the system. A series of projects and software development meetings was undertaken to formalize a document which is the project plan. In this state, mutual terms and agreements were developed and documented, and project plan was developed which details the general and specific unit requirements of the system.

In relation to requirements/planning phase, the proponent investigated the current system. A meeting was conducted to come up and agree with the project scope and system requirements.

User design stage

In the User design stage, a system model has been developed, and an outline and prototype are being designed. An implementation plan was also considered to allow the end-user involve in the analysis and design activities. This stage is the departure to the RAPID Construction Stage.

In relation to user design stage, the proponent interacts with the user, builds the model, and prototypes of the system.

Rapid construction stage

In the RAPID model-Construction Stage; a system under study or being proposed was developed. The model and prototype being developed here were based on the approved formal design and model during the user design stage. Once, a unit or module of the application has been done, testing succeeds. In the event, that the testing was successful, the user can allow or create a request and agreement with the end-users to deploy the successful version to the application server.

In relation to the rapid construction stage, the proponent performs the coding/program development. Unit, integration, and system testing were also performed in this stage.

Transition stage

This is the last stage of the RAPID software development model. The system being developed and tested in the construction stage is attributed to be “fit for use” by the end-users and operational in nature. Migration from the old system will be performed so that the organization can convert its existing data and be migrated to the new application.

In relation to cutover stage, the proponent will install the developed system and complete the necessary hardware and software configuration. A list of configuration items which are the services and offenses including measures will be inputted to the system. A user-training was conducted to allow the end-users get acquainted with the software application.

Other Tools Used in the Research Study

During the development of the software application, the researcher will use Microsoft.net 4.5 for the environment framework and ASP.NET MV5 as the development framework. Microsoft Visual C# will be used as the programming language. Text messaging feature will be integrated into the software application using SMS technology.

RESULTS AND DISCUSSION

The research study used an input-oriented radial measure of efficiency, the technical and scale efficiency is automatically computed by the software. The DMUs that obtained a score of 1.00 are the efficient colleges.

Table 1: 3-year scale efficiency results of the seven (7) colleges

DMU	2012-2013		2013-2014		2014-2015		Average	Ranking
	Technical Efficiency Score	Scale Efficiency Score	Technical Efficiency Score	Scale Efficiency Score	Technical Efficiency Score	Scale Efficiency Score		
CSCS	1.00	1.00	1.00	1.00	0.85	0.85	0.95	5
CLAC	1.00	1.00	0.87	0.87	1.00	1.00	0.96	4
CTHM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1
COEd	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1
CCJE	1.00	1.00	1.00	1.00	0.91	0.91	0.97	3
CEAT	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1
CBAA	0.97	0.97	1.00	1.00	1.00	1.00	0.99	2

CTHM, COEd and CEAT got an average efficiency score of 1.00 for three (3) years being the efficient DMUs.

Cross Tabulation

Table 2: Colleges vs. category_offense cross tabulation

Count	Category_Offense				Total
	Category1	Category2	Category3	Minor	
CBAA	104	31	4	1379	1518
CCJE	6	5	2	121	134
CEAT	59	36	4	1213	1312
College CLAC	53	37	0	869	959
COED	8	6	3	161	178
CSCS	48	26	1	948	1023
CTHM	49	40	4	848	941
Total	327	181	18	5539	6065

Table 2 presents the cross tabulation of Colleges and Category Offense. The results show that category 1 obtained a total of 327 offenses, category 2 with 181 offenses, category 3 with 18 offenses and minor with 5539 offenses out of 6065 total offenses. In relation to Colleges and Category_Offense, minor obtained the highest number of offenses.

Minor Offenses

Table 3: List of minor offenses committed in SY 2012-2013

Offense	Instance	Percentage
Dresscode	4494	68.07%
Wearing Slippers	486	7.36%
Unpinned ID	436	6.60%
Unprescribed shoes	399	6.04%
Earrings	250	3.79%
Improper pinning of ID card	182	2.76%
Body Piercing	79	1.20%
NoID card	64	0.97%
Sitting on table	64	0.97%
Loitering	14	0.21%
Using gadgers during class hours	11	0.17%
Dresscode and Wearing Slippers	5	0.08%
ID card not validated	5	0.08%
Habitual disregard of established policies for dormitory curfew	4	0.06%
Earrings and Dresscode	2	0.03%
Entering or being in the university premises while under the influence of liquor	2	0.03%
Improper grooming	2	0.03%
Lost ID card	2	0.03%
Sitting on the Parapet	2	0.03%
Violation of swimming pool policy	2	0.03%
Damaged ID card	1	0.02%
Dresscode and Improper grooming	1	0.02%
Habitual disregard of existing policy	1	0.02%
Improper grooming and Unprescribed shoes	1	0.02%
Unclaimed registration form	1	0.02%
Wearing Slippers and Dresscode	1	0.02%
Wearing Slippers and Dresscode	1	0.02%

Table 3 presents the list of minor offenses committed in SY 2012-2013. The top 5 minor offenses committed are the following: Dress code being the highest has 4494 instances equivalent to 68.07%, Wearing slippers with 486 instances equivalent to 7.36%, Unpinned ID with 436 instances equivalent to 6.60%, Unprescribed shoes with 399 instances equivalent to 6.04%, and Earrings with 250 instances equivalent to 3.79%

Table 4: List of minor offenses committed in SY 2013-2014

Offense	Instance	Percentage
Dresscode	927	51.90%
Earrings	92	5.15%
Body piercing	88	4.93%
Unprescribed shoes	18	1.01%
Unpinned ID	17	0.95%
No ID card	15	0.84%
Sitting on the table	10	0.56%
Wearing Slippers	10	0.56%
Using gadgets during class hours	8	0.45%
Lost money	6	0.34%
Improper pinning of ID card	4	0.22%
Habitual disregard of existing policies	3	0.17%
Lending of ID card to someone else	2	0.11%
Wearing shorts	2	0.11%
Habitual disregard of established policies for Dormitory Curfew	1	0.06%
Lost laptop or netbook	1	0.06%

Table 4 presents the list of minor offenses committed in SY 2013-2014. The top 5 minor offenses committed are the following: Dress code being the highest has 927 instances equivalent to 51.90%, Earrings with 92 instances equivalent to 5.15%, body piercing with 88 instances equivalent to 4.93%, Unprescribed shoes with 18 instances equivalent to 1.01%, and Unpinned ID with 17 instances equivalent to 0.95%.

Table 5: 3-year scale efficiency results of the Philippines national police-district VI in the province of cavite

Minor Offenses	Instance	Percentage
Dresscode	4670	76.33%
Earrings	310	5.07%
Unpinned ID	210	3.43%
Body Piercing	98	1.60%
No ID card	69	1.13%
Sitting on the table	64	1.05%
Unprescribed shoes	44	0.72%
Using gadgets during class hours	27	0.44%
Playing cards	15	0.25%
Wearing Slippers	13	0.21%
Improper pinning of ID card	9	0.15%
Loitering	7	0.11%
Smoking	3	0.05%
Commission of third minor offense	2	0.03%
Eating inside the classroom	1	0.02%
Sitting on the parapet	1	0.02%

Table 5 presents the list of minor offenses committed in SY 2014-2015. The top 5 minor offenses committed are the following: Dress code being the highest has 4670 instances equivalent to 76.33%, Earrings with 310 instances equivalent to 5.07%, unpinned ID with 210 instances equivalent to 3.40%, body piercing with 98 instances equivalent to 1.60%, and no ID card with 69 instances equivalent to 1.13%.

CONCLUSION, RECOMMENDATIONS AND IMPLICATIONS

The purpose of the study is to implement knowledge discovery in enhancing the university services portfolio. The research study used an input-oriented radial measure of efficiency model using data envelopment analysis to classify the efficiency of the colleges in reducing student violations. Based on the 3-year historical data, three (3) colleges were classified as efficient DMUs which were the COEd, CTHM, and CEAT. Based on the result of the cross tabulation per college, minor offense obtained the highest number of offenses with 5539 offenses out of 6065 total offenses.

CHAID algorithm was used to determine the pattern of the student offenses. Using the pattern derived, a remediation application software is developed to help the seven (7) colleges and the SWAFO lessen the number of student offenses.

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