ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 04, pp.49188-49195, April, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

A RESOURCE ALLOCATION MODEL FOR ADMISSION INTO NIGERIAN UNIVERSITIES

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ARTICLE INFO

Article History:
Received 30th January, 2017
Received in revised form
15th February, 2017
Accepted 12th March, 2017
Published online 30th April, 2017

Key words:

Alternative course allocation,
Pre-degree,
Remedial Courses,
RAM.

ABSTRACT

There are numerous ways of admitting students into the University system in Nigeria. These methods include admission through the Unified Tertiary Matriculation Examination (UTME), part time programs, diploma programs and the pre-degree program. In recent times, applicants who seek admission into the University system through the pre-degree program but fail to meet the requirement of their preferred course of study are usually allocated an alternative course of study. This process is however usually done without considering the academic strength and ability of the applicant. Hence, the academic performance of the candidate in the alternative course of study is usually poor. This is because the candidate is usually not psychologically prepared for the alternative course of study. Consequently, this paper studies the existing process of admitting students into the University system in Nigeria through its pre-degree program. This is achieved by interviewing stakeholders in the admission process. This study considered ObafemiAwolowo University, Ile-Ife, Nigeria as its case study. The study also designed a framework that carefully allocates students into an alternative course of study by considering their academic strength and ability. This is with a view to assisting stakeholders in making effective decisions on alternative course allocation.

Citation: Ikono Rhoda, BabalolaAbimbola and IrojuOlaronke, 2017. "A resource allocation model for admission into Nigerian universities", *International Journal of Current Research*, 9, (04), 49188-49195.

INTRODUCTION

The University is a complex organization whose behavioral patterns are influenced by a wide range of inconsistent cultural norms (Thomas, 1996). There are several resources available in the University such as financial resources, technological resources, human resources and academic resources. The allocation of these resources has become a global phenomenon which has been receiving attention in the last decades (El-Sheikh *et al*., 2012). In addition, the allocation and planning of University resources is a highly complex administrative procedure that is based on an extensive analysis of large volumes of data. However, the exponential growth in the population of students that enroll into the University annually is a major challenge that is confronting the allocation of resources in the University. The allocation of academic resources such as teaching resources, offered degrees/ course of study, etc to this large population is fraught with numerous difficulties. For instance, applicants usually seek admission into universities annually through the Unified Tertiary Matriculation Examination (UTME) conducted by the Joint Admission and Matriculation Board (JAMB) in Nigeria.

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The Joint Admission and Matriculation Board ensure a unified standard for the conduct of matriculation examination and the placement of suitably qualified candidates into the nation's higher education system. However, less than 20 percent of the applicants are admitted into the university system (Moti, 2010). Hence, alternatives such as part-time programs, diploma programs and pre-degree programs are usually provided for applicants who were not offered admission into the University. In recent years, quite a number of applicants seek admission into the University through the pre-degree program which usually runs for a year. Diverse assessments and examination are usually conducted during this year. One of the basic requirements for admission into a relevant degree program of a University through the pre-degree program is obtaining at least a minimum percent aggregate (decided by the university) in a candidate's course combination area. Nevertheless, each department in the University also has a benchmark which is compared with the candidate's aggregate score. Nonetheless, a candidate is offered an alternate course of study if the aggregate score is less than the benchmark. This is normally done without considering the academic strength and ability of the applicant. Consequently, the academic performance of the candidate in the alternative course of study is usually poor. This is because the candidate is really not psychologically prepared for the alternative course of study. Also, the process involved in allocating an alternative course of study to the

candidates is a manual process. Subsequently, this process is prone to human errors, bias and irregularities. Hence, the candidates end up in departments they do not deserve (Wabwoba and Mwakondo, 2011). This necessitates the design of a resource allocation model that will perform the allocation of alternative courses to students automatically by considering their academic strength and ability. This is with a view to improving the admission process into a University through its pre-degree program. Hence, this work will ameliorate the challenges involved in the admission of students into the University through the pre-degree program. In addition, academic admission administrators in Nigeria will benefit immensely since the stress involved in the manual process will be eliminated.

This paper therefore highlights methods of resource allocation and applicable decision theory that supports quality and timely decision making. This study also examines the existing process of admitting students into the University system in Nigeria through its pre-degree program. This study considered ObafemiAwolowo University, Ile-Ife, Nigeria as its case study. The remainder of this paper is as follows: section 2 appraises the general overview of resource allocation in Nigerian university, section 3 discusses resource allocation models, section 4 highlights the approaches of decision theory, section 5 examines related works, section 6 discusses the admission process of ObafemiAwolowo University through Pre-degree program, section 7 discusses the proposed model while the section is concluded in section 8.

Overview of resource allocation in Nigerian universities

Resources can be defined as the actual or potential wealth that will meet a need and facilitates success (Wabwoba and Mwakondo, 2011). They are assets used to produce goods and services to meet human needs and wants (McConnell *et al*., 2011). Resources are also considered as all the things available for an individual, a group of individuals, an organization, institution, association and any combination thereof, to be used for the purpose of achieving pre-determined aims and objectives (Horny, 2001). In education, resources are the sum total of everything that goes into the educational system to encourage, support, promote and facilitate teaching-learning process (Okunola, 1986; Agun, 1988). Traditionally, resources in a university are categorized into: financial resources, technological resources, human resources and academic resources Financial resources refers to the various funds used for the achievement of educational goals (Asechemie, 1999) Technological resources such as instructional courseware, digital content and other electronic learning resources are used to improve students' achievement, human resources and academic resources (Grinager, 2006); Human resources include all the individuals and/or group(s) of individuals who are directly involved in the teaching – learning process (Meenyinikor, 2012). Academic resources include instructional materials, offered degrees or course of study, course structure and curricula, enrollment and retention (Mansmannand Scholl, 2007). The process of assigning these assets in a manner that improves efficiency and productivity is called Resource Allocation. Resource Allocation is concerned with sharing contested resources between several parties (Walsh, 2015). The allocation of academic resources is guided by some conditions known as the university admission policy or requirement. The allocation of academic resources is different from the allocation of other resources becauseacademic resources are assigned without regard to a cost function (Walczak, 1998). The allocation of resources in Nigerian universities facilitates the even distribution of resources. Though it offers solution to the issue of who gets what, when and where the resources will be shared among different parties, it is fraught with numerous challenges. For instance, a typical challenge in allocating financial resources is unforeseen cost. This is because the cost of employing a personnel can be easily included in a budget, but determining the cost of effectiveness of such personnel may be hard. Furthermore, academic resources, such as well-equipped laboratories and lecture halls are usually in short supply to students.

Resource allocation models

A Resource Allocation Model (RAM) is a methodology that ensures that available resources are used judiciously to achieve the objectives of an institution to a high level of satisfaction (Solanke and Olatunji, 2015). RAM provides incentives to academic units using an approach that enables those units to contribute to the success of the institution as a whole (Morgan, and Prowle, 2005; Shattock and Rigby, 1983). It incorporates a decision support system into its functionality to aid decision making. It has the potential of improving decisions by suggesting solutions that are better than those made by human alone which is prone to bias. This methodology also helps to settle trade-offs and prioritize information in situations where precision and optimality is important even if the inflow of data is high (Druzdzeland Flynn, 2002). Hence, RAMs are the means by which an organization's resources are distributed (Field and Klingert, 2001).According to Engineering Ethics, available resources may be shared by merit, social worth, need, and random or equal assignment. In Nigeria, offered degrees are allocated to candidates basically by merit which is based on demonstrated ability by the candidate, and in special circumstances by random or equal assignment. For randomallocation, a RAM will assist in decision making for recommendation and allocation as substitute for human judgment which is prone to bias when the individual is stressed or emotional. RAM is a form of decision support system. A Decision Support System (DSS) is a tool that aids the process of decision making in intricate systems, predominantly where information is indecisive or partial (Michael, 2005). DSS is the area of Information Systems (IS) discipline that focuses on civilizing managerial decision-making (Arnott, 2005). It makes decisions based on algorithms derived from an understanding of the application domain (Ajayi *et al*., 2014).

Decision theory

This work is hinged on the theory of descriptive decision making. Decision-making is the most important liability of all school managers (Fakeeh, 2015). It is very important that education administrators have an understanding of the decision-making process of their institutions. According to Druzdzel and Flynn (2002), there are different types of decisions. These include:

- **Structured Decision:** this is a set of steps that yield the correct result if followed in a particular way. It does not involve any feeling or intuition and it can be easily programmed, that is, it contains inputs, processes and, outputs).

- **Non-Structured Decision**: this is a form of decision in which there are no rules or criteria that will guarantee a good solution. There are usually several right answers.
- **Recurring Decision**: this is a form of decision that happens repeatedly and periodically (daily, monthly, annually).
- **Non-Recurring Decision**: this is a decision made infrequently. It is usually based on different criteria for determining the best solution each time.

Making precise decision is vital in educational management, especially in admission administration. With decision theory, the best approach for making a decision can be determined, based on the structure of the decision which is necessary since such decision affects or determines the recipient's career path in life.

Decision theory is the study of principles and algorithms for making correct decisions—that is, decisions that allow one to achieve better outcomes with respect to the stated goals (Power, 2002). The two distinct approaches of decision theory suggested by Druzdzel and Flynn (2002) are:

- **Normative Approach:** This approach of decision theoryuses norms and standards for dealing with complex decisions. An example of such is the probability rule which provides standards for evaluating a judgment or decision (Baron, 2004). Normative theory is concerned with the rationality and the logic of decision making.
- **Descriptive Approach:** This uses the assumption that the decision-makers are behaving under some consistent rules. Its aim is to build support systems that imitate human experts. This theory opines that decision makers choose an alternative that exceeds some criterion or standard. An example is the expert systems, which are computer programs based on rules elicited from human domain experts that imitate reasoning of a human expert in a given domain. Descriptive approach uses machine learning for judgments and decisions in its implementation. These learning techniques increases the effectiveness of support provided for decision making (Zopounidis and Doumpos, 2002).

Machine Learning is an aspect of artificial intelligence that gives computers the ability to learn without being explicitly programmed. It explores the study and construction of algorithms that can learn from and make predictions on data (Kohavi and Provost, 1998). It allows computers to learn from past examples using examples using statistical and optimization techniques (Quinlan, 1986; Cruz and Wishart, 2006). There are numerous machine learning techniques that can be classified in several ways. Machine Learning uses learning algorithms for picking up subtleties in data which may be hard to code for. Learning algorithm is an adaptive method by which a network of computing units self-organizes to implement the desired behavior (Rojas, 1996). Machine Learning helps with the process of acquiring knowledge and its algorithms are classified majorly as supervised learning and unsupervised learning (Russell and Norvig, 2003). A commonly used supervised learning technique is the artificial neural network (ANN) (Merkert *et al*., 2015). ANN is a biological inspired intelligence model of mathematical construct, capable to learn through examples and to generalize, i.e. to produce coherent results to data not explored during learning process (Haykin, 2008). It derives its computing power, its ability to learn and generalize through its massively parallel distributed structure (Hajek, 2005). It is the most frequently applied technique because of its ability to find non-linear relationships between independent and dependent variables and the availability of multiple training algorithms (Merkert *et al*., 2015).

Related work

Research findings have shown that most of the studies on resource allocation in higher education institutions focus more on the monetary resource allocation (El-Sheikh *et al*., 2012; Angluin and Scapens, 2000; Dickson, 1999). Also, allocation systems designed for admission focused only on candidates who have qualified based on merit only. Some of these studies are as summarized:

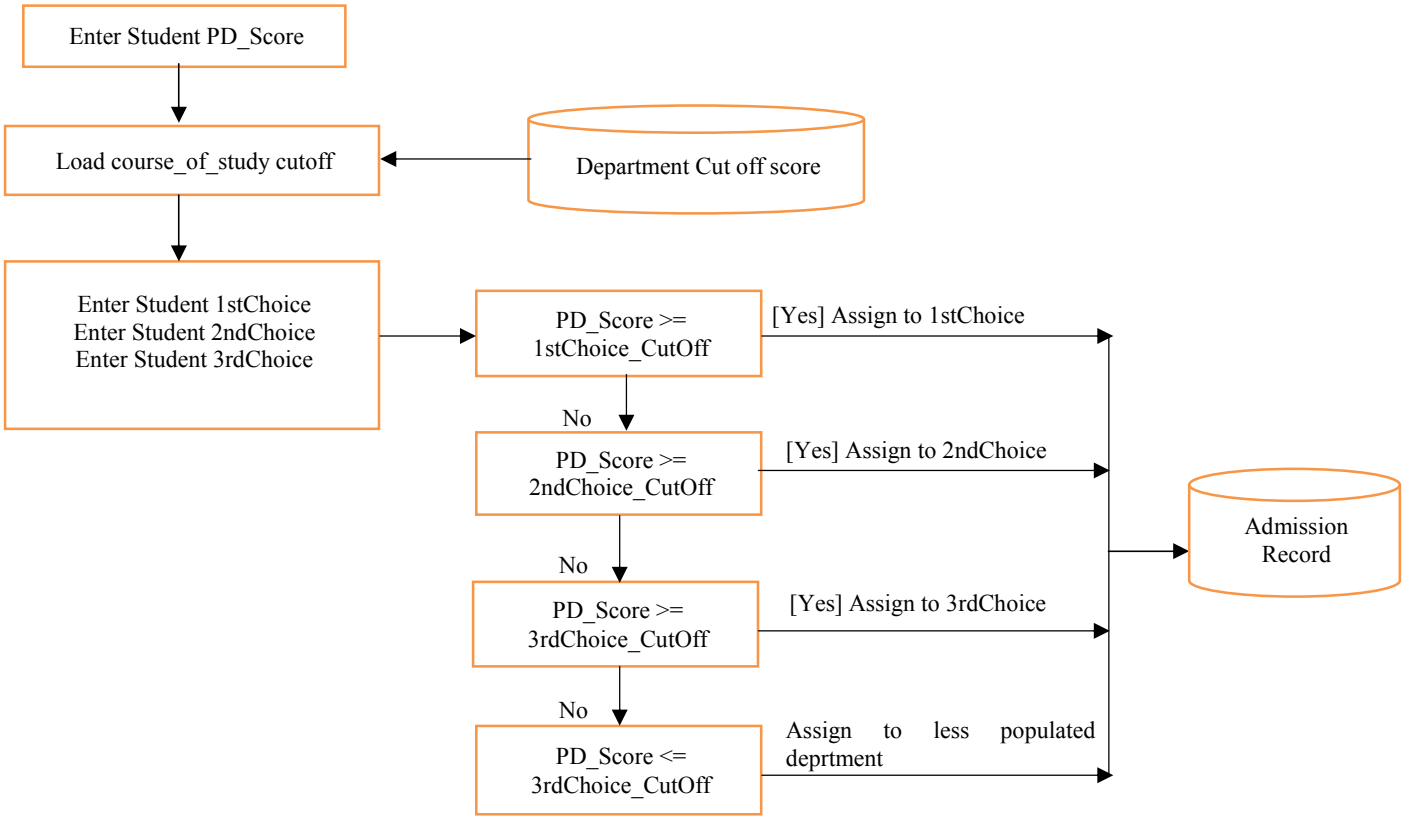
Angluin and Scapens (2000) researched how universities allocate resources to academic subjects by focusing on the accounting and finance academic group. The study expressed differences among universities in the use of financial information by academic management and in transparency to academic subject groups of university planning and resource allocation. Liefner (2003) examined the forms of resource allocation in universities and the effects of these forms on performance in institutions of higher education. The study showed that the way resources are allocated in a university affects the behavior of students, staffs and administrators and influences the activities they engage in. Mah'd (2014) explored the methods used to allocate resources in higher education in Jordan. This research focused on the methods used in private Jordanian universities. It employed the use of questionnaire to gather data. The result showed that university objectives and goals were defined in broad and ambiguous terms and allocation of available resources was not dynamic and very inflexible. None of these works considered offered degree as a resource though attempts have been made to develop systems that assist in university admission processes. Solanke and Olatunji (2015) also explored resource allocation in higher education institutions in Nigeria. The research examined how academic leaders managed resources in polytechnics. The researchers argued that inconsistencies in resource allocation affects technological and developmental transformation within the polytechnic system.

Alotaibi *et al*. (2016) developed a framework for admission system in Saudi universities. The study recommended the application the modern approach proposed in the study to decision making in admission systems in order to improve the efficiency of Saudi universities. The system only identified candidates with required grades needed for a single preferred course of study into the university. Mabu and Muhammed (2016) developed a support system that helps Nigerian universities in screening students during admission process. The system was developed using ID3 algorithm. The system was implemented using C++ programming language. The study concluded that the use of a decision support system for student enrollment will increase the accuracy and speed of the admission system. The system is mainly interested in identifying the best applicants for admission purpose and gives little or no consideration to others. Fakeeh (2015) developed a Decision Support System for handling academic planning involving students, teaching staffs and research staffs. The result was a decision support model that is appropriate for academic planning and organization. The study concluded that

incorporation of a DSS with the higher education or university ICT systems will accomplish a reduction in cost and time required to take the most fitting decisions. Tanna (2012) developed a decision support system that helps candidates decide which field of Engineering suit them. The system takes mean of current and previous Common Eligibility Tests (CET) scores of students who applied for the field. The mean is then compared with the candidates score in order to classify him as best bargain, ambitious or safe with respect to the field. In the study, the mean served as a feedback to the system and it was observed that the use of the mean provides a linear feedback which takes the system a long time to self-correct errors. The study showed that arithmetic mean is very sensitive therefore few or large values in a sample may lead to the wrong prediction. It also concluded that machine learning techniques are generally better predictors than statistical techniques. Muhammad and Khan (2011) developed a rule based Decision Support System that helps students in selecting a suitable faculty during admission exercise. The application was developed using CLIPS(C Language Integrated Production System) programming language. The system consists of a general rule-base and an inference engine. The rule-base engine generates rules based on a training set. These rules are retrieved by the inference engine and are used to solve new problems. The system uses "IF-THEN" conditions which reduces the accuracy of prediction. However, none of these studies was designed for admission process into the university through pre-degree studies. This study attempts to provide a tool for effectively handling this process.

A study of the university admission process through the pre-degree program of Obafemi Awolowo university, Ile-Ife, Nigeria

A basic requirement for a candidate to be offered admission into the pre-degree program of ObafemiAwolowo University (OAU), Ile-Ifeis for the candidate to possess at least five credit passes at not more than two sittings of the Ordinary level (O'level) examination. The O'level examination is usually conducted for students at the end of a six-year study in secondary schools. There are three independent bodies that conduct these examinations. These are West Africa Examination Council (WAEC), National Examination Council (NECO) and National Business and Technical Examination Board (NABTEB).At the start of the pre-degree program, each candidate is assigned a unique pre-degree (PD) number for identification purpose. This number is extremely important because it distinctively identifies each of the candidates. Also, applicants are required to submit three departments as their choice in order of preference. The pre-degree program usually lapse for a year. During this period, the candidate attempts all the required tests and examinations. At the end of this process, the pre-degree aggregate score is calculated by finding the average of all the scores obtained by a candidate in the tests and examination. At this point, the University administrators set a minimum acceptable score, usually 60%, for consideration into any discipline for undergraduate program in the university.



1Figure 1. Obafemi Awolowo University Admission System into Undergraduate Program via its Pre-Degree Program

Candidates' score must not be lower than this setgeneral cut-off score which is used as the first criterion to determine the eligibility of candidates into any of the undergraduate program of the university. If the candidate's aggregate score is lower than the pre-degree cutoff, the applicant is not qualified for any undergraduate program in the university. On the other hand, if the aggregate score is equal or higher than this benchmark, the candidate is cleared for further consideration. For the admission process, every course of study that has candidates from the pre-degree program is assigned a cut-off mark which varies from one course of study to the other. The process continues by comparing the candidate's aggregate score with the cut off mark of departments on candidate's preferred lists, starting from the most preferred. If the candidate's aggregate score is equal to or higher than the cut-off mark of the candidate's most preferred department, the candidate is offered admission to the most preferred choice. If the aggregate score is found to be lower, it is compared with the cut –off score of the next preferred course of study. If the score is equal or higher than this cut-off, the candidate is offered admission to the next preferred choice. But if it is lower also, it is further compared with the cut-off of the last choice on the candidate's list. If the candidate's score does not satisfy any of the chosen courses of study, the candidate is allocated an alternative course of study that usually has a lower number of applications. This is done at the discretion of the admission officers who do not consider the academic strengths of the applicants. In addition, this process is manual, time consuming, bias as well as error prone. This manual process is shown in Figure 1.

The admission process of candidates into ObafemiAwolowo University undergraduate programs via its pre-degree program is represented in Algorithm 1.

Algorithm 1: Course Allocation Process for Admission into ObafemiAwolowo University via the Pre-Degree Program

```
1.  Input PD_cutoff, course_cutoff1, course_cutoff2, course_cutoff3;
2.  If (PD_score>= PD_cutoff) Then
3.  Student is granted admission
4.  Else
5.      Student is not granted admission
6.  End
7.  If (PD_score>= most preferred course_cutoff) Then
8.      Department= course1
9.  Else If (PD_score< most preferred course_cutoff and PD_score>= course_cutoff2) Then
10.     Department=course2
11. Else if (PD_score< most preferred course_cutoff and PD_score< course_cutoff2 and PD_score>= course_cutoff3) Then
12.     Department=course3;
13. Else
14.     Student is allocated an alternative course
15. End
```

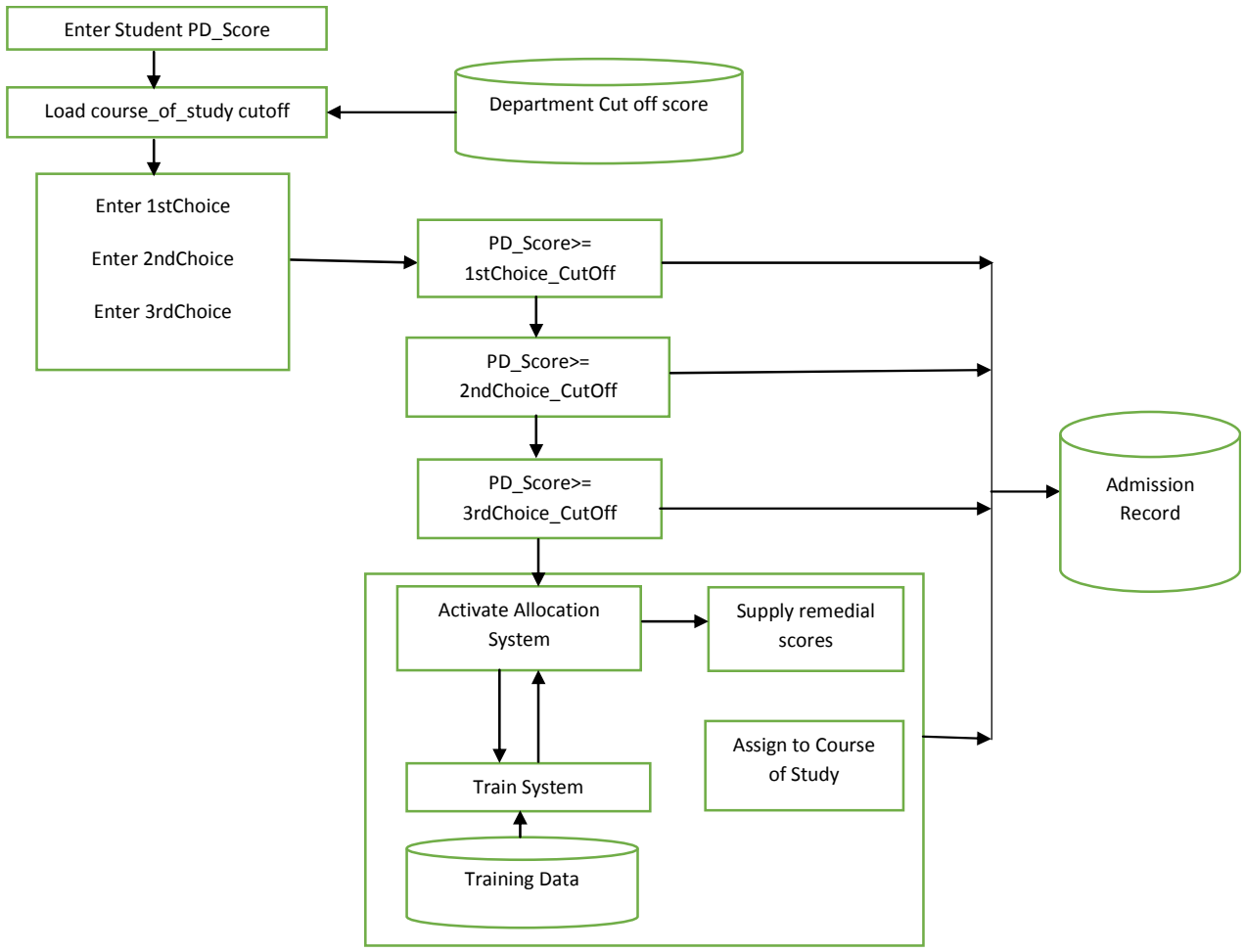


Figure 2. Resource Allocation model for Pre-degree Admission in University

Algorithm 2: The Proposed RA Model: see algorithm

1. Input PD_cutoff, course_cutoff1, course_cutoff2, course_cutoff3;
2. If (PD_score >= PD_cutoff) Then
   a. If (PD_score >= course_cutoff1) then Department= course1;
   b. Else If (PD_score>= course_cutoff2) then Department=course2;
   c. Else if (PD_score>= course_cutoff3) then Department=course3;
   d. Else
      i. Load Training Data
      ii. Train ANN;
      iii. Input Score for each Pre-degree subject;
      iv. Allocate Alternative Course of Study;
   e. End If;
3. Else No Offer of Admission;
4. End If;

Proposed resource allocation model

The allocation of course of study to candidates seeking admission into the university through Pre-degree can be a challenge for the administrators, especially for candidates who are to be offered alternative degrees other than their preferred choice. This is because of their failure to make the cut off of their preferred choice. This section proposes a framework that will place candidates into an alternative course of study by taking into cognizance the academic ability and strength of students.

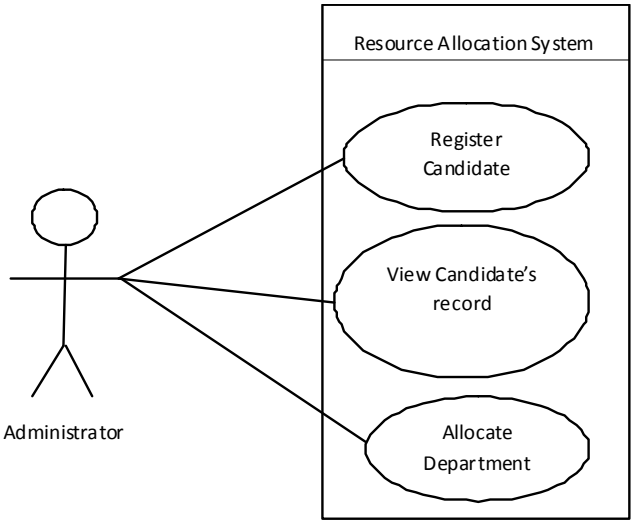


Figure 3. Use case diagram for Resource Allocation model

The scores obtained in eachpre-degree subjects of the relevant combination for a candidate during the program is used as the indication of academic ability. These results are processed form the training data used in the model. There source allocation model is as shown in Figure 2. The model is trained with a machine learning technique, (artificial neural network) to aid the decision making process. After this is done, the scores obtained by the candidate in each of the subjects attempted during the pre-degree problem is supplied as input and the model uses this for the allocation. The operation of this model is represented in algorithm 2:It is expedient that the requirements of the RA Model are identified. These requirements are emphasized using the use case and sequence diagrams of the Unified Modeling Language (UML). The use case diagram is designed to graphically depict the interactions between the system and its users. It describes who use the system and in what way the user interacts with the system. The following components used for the design of the use case diagrams include the actor and use case.

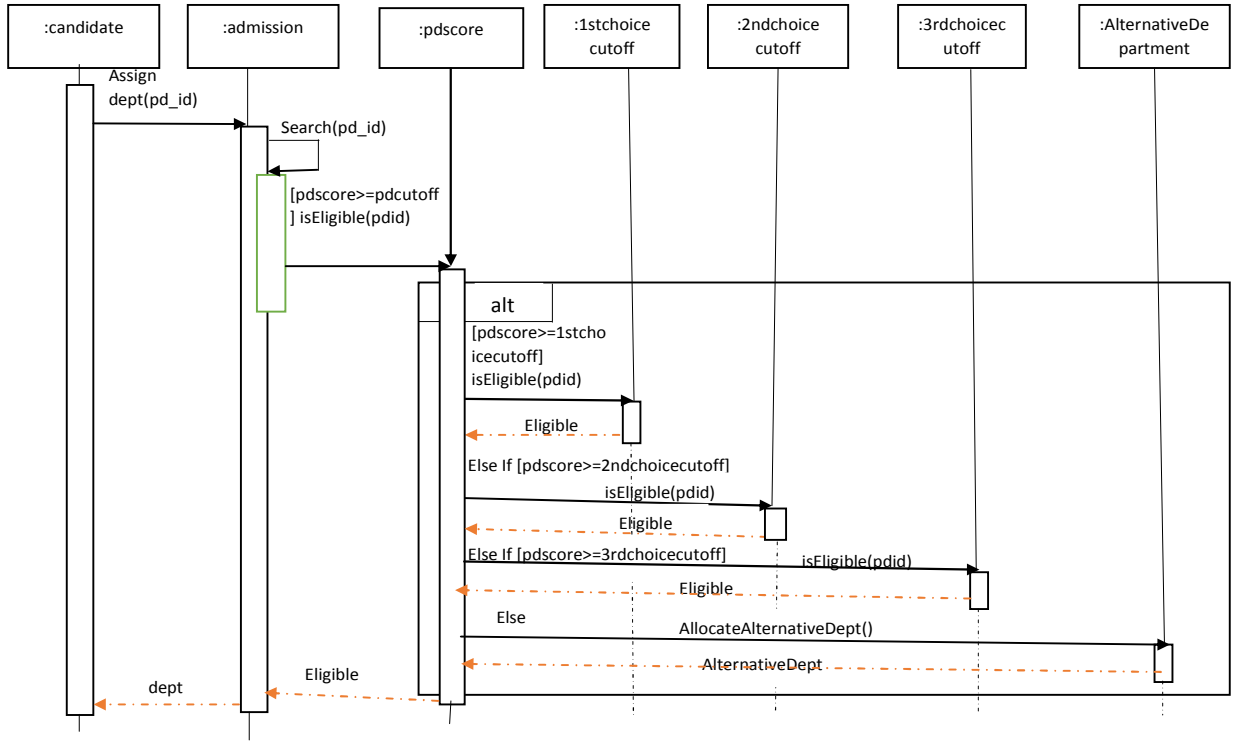


Figure 4. Sequence diagram for the Alternative Resource Allocation Model

The actor is represented as a stick figure. It lies outside the system model and interacts with it (Iroju and Ojerinde, 2016). The use case diagram shows the operations performed by the administrator during the admission process. These operations include candidate registration, viewing the record(s) of admitted candidates and allocation of students into the various departments. The administrator registers the candidate by assigning him a registration number, retrieves information that is particular to a candidate when necessary by viewing the records and completes admission process by allocation a course of study to candidate(s). The use case diagram is as shown in Figure 3. The sequence diagram depicts the objects and the interactions between the objects found in the system. The sequence diagram also shows the message passed from one object to the other. The objects that are identified in the proposed model include candidate, admission, firstchoice_cutoff, secondchoice_cutoff, thirdchoice_cutoff and alternativedepartment. In the sequence diagram of the proposed model, a message is passed from object candidate to object admission. This is to assign the candidate to a department using the candidate's registration number as a parameter (assigndept(pd_id)). The "admission" object performs a recursive operation (search(pd_id)) to check if the candidate is registered. If the candidate is registered, the candidate's overall score is compared to the Pre-Degree cut off scoreto check if the candidate is eligible for consideration for admission (isEligible(pd_id)). If the candidate is eligible, control loop (alt) is activated and a check (pdscore>=1stchoicecutoff) is done to see if the candidate qualifies for the first choice (***isEligible(pd_id)***). If the check returns false, pdscore is compared with the second choice (pdscore>=2ndchoicecutoff). See algorithm 1 for the condition If the check returns false, the pdscore is compared with the third choice (pdscore>=3rdchoicecutoff). See algorithm 1. If this check also returns false, then the resource allocation module for alternative course of study is activated and allocates the candidate. The sequence diagram that represents this process is shown in Figure 4.

Conclusion

One of the major ways of seeking admission into Nigerian Universities is through the pre-degree program. However, the admission process into Nigerian universities through the pre-degree has been fraught with a number of challenges. This is because the process is manual, time consuming, bias and it is associated with a lot of irregularities. One major irregularity associated with the admission of students seeking admission into the University through the pre-degree is that students who fail to meet the requirement for admission into their preferred course of students are usually placed into an alternative course of study without the consideration of their academic strength and ability. Hence, the academic performance of such students is usually poor because they are not usually psychologically prepared for the alternate course of student. As a result of this, this paper designs a model that allocates students into various departments in the university by taking into consideration the academic strengths and abilities of the students.

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