EUROPEAN JOURNAL OF PURE AND APPLIED MATHEMATICS
Vol. 17, No. 3, 2024, 1959-1981
ISSN 1307-5543 – ejpam.com
Published by New York Business Global

Multi-Criteria Decision Making for Determining Critical Success Factors in Achieving Top University Graduation

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Abstract. Within the context of students' academic achievements, the aspect of "peak-performance" among students in HEIs, still remain underexplored. Graduating with/at maximum achievement is a desired goal for any student into HEI, and can never be less important. Admittedly, what students do during school periods truly can help create the high grades border difference in respect to maintaining and achieving their initial educational goal. This study seeks to identify and distill from an academic perspective, key independent variables/factors called CSFs that are decisive and significantly impact on the ability of students in HEIs to graduate with/at maximum achievement. We gleaned a set of CSFs from the literature, then refined the list to 32 so that the final list reflects broadly 6 main CSFs that relate to HEI studentship: - Behaviour towards academics, Hard work, Organization, Peers and Socials, Skills, and Studying Style or Pattern. We then applied a Multi Attributes Decision making tool, AHP on the set of CSFs. The AHP prioritizes a subset of these CSFs as being most likely contributive variables to finishing top in university. The approach in this study is unique and provides a strategic framework for decision-making. Prospective and current students, parents, educators, academic institutions and the society at large who depend on these graduates will find the study results cardinal.

2020 Mathematics Subject Classifications: 97M40, 90C29,90B50, 91B06. 97M70 97B40

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DOI: https://doi.org/10.29020/nybg.ejpam.v17i3.5149

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Key Words and Phrases: Analytic Hierarchy Process, Critical Success Factors, Graduating at maximum achievement, Pair-wise comparison matrix, Priority Vector

1. Introduction

Over the last decades, there has been a dramatic change in the higher education environment globally. Educational privatization, online learning, and the rising cost of education are some of the key elements that characterized this change [18]. Yet globally, in today's society, 8 out of every 10 (about 80 percent) high school graduates yearn to attain post-secondary and higher levels of education [29]. Once in university, students' likelihoods for academic ability to succeed top-performing can be different dynamically and to a greater degree. Many of these students do not achieve their post-secondary educational goals or least benefit at optimal levels from the actual university experience in terms of their performance. Some students more than others are better prepared academically. That some students come out on top while others do not is indisputable.
According to [[33], [13]], only about a few students who begin their studies end up having high grades and for postgraduate masters could also earn them qualifications for Ph.D. admissions. There exist high grades achievement disparities among students in higher education institution (HEIs). For every student into HEIs, graduating with/at maximum achievement is a desired goal, and can never be less important or overemphasized. While the emphasis in this study is not particular to a university, department or discipline, we recognized that almost every HEI globally uses a slightly different grading system/policy. In the light of this, we adopt a synchronized version that appears to cut-across all universities globally, as in Table 1. However, while really in school, many malleable factors could

Table 1: Basic grade system, [10]

Score Grouping	Letter Grade	Implication in this study
80 – 100	A	Desired decision
70 – 79	B	Undesired decision
50 – 69	C	Undesired decision
0 – 49	F	No student desire

be responsible for deviating from or not achieving this goal. Admittedly, what students do during school hours- the activities they engage in and the company of friends they keep, and their overall mindset towards academic practices and behaviors such as attendance, studying and applying effort in class works and on homework and assignments truly can help create the high grades border distinction in respect to maintaining and realizing their initial educational goal [[20], [1], [8]]. So why do some students consistently top-perform and improve faster than others? Graduating with/at maximum achievement in university has never been more important. There is need to understand the variables that play out critically in obtaining higher grades in universities. While the focus on students' academic success and performance keeps growing both in scope and dimensions, limited attention is given to students in universities. Even more neglected is the grades nature of this unique class of students. To find out why some students performed at maximum achievement where others do not, we examined what these high-performing students have in common and what others can do to maintain or improve their outcomes or grades. To this end, this study seeks to unearth the critical success factors (CSFs) that are pivotal for a student to have high grades. These CSFs reflect complete behavioral change and alignment that must be fully demonstrated by students. They are niche areas for the already top-performing students, and will serve as key focus areas for those who which to perform better or come out on top in universities if put into practice effectively. There is need for improvement planning for non-top-performing students,and will find these key elements useful for implementing their improvement efforts, as [20] CSFs are planning tools. Every student performance can be increased, as there are many different ways to improve. Therefore, we take a cumulative and longitudinal view of what matters most to a student to earn a high grade.

Till this moment, all similar publications are centered on the qualitative determination of CSFs important for institutional success, and students' academic success and performance. However, our paper is different, both in terms of the problem definition and the decision-making approach as it focuses quantitatively/mathematically on the CSFs crucial for students getting high grades. This paper contributes to the literature by proposal of a Multiple-criteria decision analysis (MCDA) or Multiple-criteria decision making (MCDM) tool, the analytic hierarchy process (AHP) with which the attainment of "A" grade is guaranteed for students in HEIs. This study seeks to unearth the CSFs that are pivotal for a student to have high grades. The rest of the paper is organized as follows: After establishing the introductory points, section 2 describes a concise literature review of CSFs necessary for institutions and students' academic success and performance and highlights the research gaps. In Section 3, we provide an overview of CSFs for graduating top of the scale, while Section 4 demonstrates the use of AHP for graduating top in HEIs. Result, analysis and discussion on findings are presented in Section 5, and Section 6 ends with conclusions.

2. Literature Review

The concept of critical success factor (CSFs) was propounded by Daniel in 1961, and made understandable by Rockart, who coined the term "Critical Success Factor" [1]. Daniel asserted that organizational planning information should focus on "success factors," which he described as "key jobs that must be done exceedingly well for a company to be successful" [[8], [21]]. In the literature there are several definitions of CSFs. For example, Rockart, in presenting one of the most frequently cited definitions, uses ideas from Daniel in defining CSFs as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization". Consequently, he stresses, that these particular areas of activity should be constantly and carefully managed by an enterprise if the business is to survive and flourish. Conversely, underperformance in these core functions would prohibit the organization from achieving its strategic imperatives. Each factor requires multiple measures focused on results [[24], [4], [7], [6]]. According to [22], CSFs are the few key areas where 'things must go right' for the business to flourish and for the manager's goals to be attained. A CSFs analysis tries to identify a small number of goals or factors that, if they are reached or successfully completed, will tend to predict or indicate success. Therefore, CSFs are the activity areas that should receive constant and careful attention. The concept of CSFs has been widely applied. CSFs differ among industries and for individual business within a particular industry. This assertion came from a study by [21] in an attempt to define CSFs that are crucial for implementing business intelligence (BI) systems in small and medium enterprises (SMEs). [22] carried out a study on CSFs and they identified those CSFs that are really significant in explaining the success of Project Management. In a study to explore the CSFs of a New Product Development (NPD), [12] discovered that the role of top Management is the most critical factor that leads to NPD success. [6] reviews and proposes five CSFs for organizations managing high-rise (non-low cost) residential buildings. Their results revealed that the CSFs can help to improve the organization's performance to understand the critical areas for successful management to meet the residents' expectations for a harmonious communal living.

While CSFs analysis has often been used to elicit information requirements in systems analysis and design, they could also be used to identify factors for institutional effectiveness and improvement, and academic success factors necessary for graduating top of the scale. Educationally, CSFs have been used as measures of institutional enhancement and effectiveness. For example, [17] identifies through explorative investigations the critical success factors (CSF) factors pertinent to school improvement under two commonly observed existing models based on their missing links. [18] explored the CSFs involved in creating a constituent relationship management (CRM) strategy that combines people, processes, and technology in a higher education institution aim at creating a lifelong relationship across the multiplexity of the university constituents namely applicants, students, alumni, employers, and companies. The study by [32] proposes a conceptual model representation of the CSFs of total quality management (TQM) for implementation in HEIs and their impacts on institutions performance. [4] reviewed CSFs responsible for graduate student's success to determine the quality of the graduate program. They used CSFs to develop strategies to create and maintain a community of connectedness for students, and initiatives to halt attrition and sustain graduate student success. In academic performance, CSFs for graduating top of the Scale are the same, though the degree, or extent of satisfying them may vary from one individual to another. [33] provided an integrated view of the causal effect of academic success by combining CSFs related to students' academic success with those factors identified in previous research studies. [13] determined that; knowledge of IT, self-confidence, the particular university that the student graduated from, and willingness to learn are the pivotal CSFs for employers when recruiting new employee from among university graduates. Based on meta-analysis techniques of previous multiple studies to determine CSFs that affect m-learning platforms in higher education settings, [2] concludes that: - collaborations during studies, prospects of ubiquitous learning in space and time, and user-friendly applications design are the most important perceived advan-

tages of m-learning. A study to understand the variables surrounding graduate faculty perspectives of graduate student success, [7] discovers that faculty perceptions indicated; variables of academics and self-responsibility to be critical to the success of graduate students. An exploration of students' descriptions of the personal resources that they use to succeed while attempting to reach their goals as well as those personal characteristics or obstacles that keep them from reaching their goals at universities is found in [29]. The study discovered prominent themes supportive of student success including having a future orientation, persistence, and strong executive functioning skills such as time management and organization, were listed as CSFs for undergraduate students to reach their goals while attending university.
From the aforementioned literature, Students' academic achievements has remained passive, with no study being reported in particular on their top performance. While graduating top of the scale is a goal often cherished by many students pursuing higher education, it is also commendable goal that demand strategic approach. However, this accomplishment is often multifaceted and influenced by both qualitative and quantitative factors that may not be immediately apparent. Graduating top of the scale is a decision-making problem that demands making a trade-off between multiple tangible and intangible, and often conflicting criteria. It is not dependent on only one criterion, but involves taking a definite number of alternative actions. Therefore, it is a classic example of a Multiple Attribute Decision Making (MADM), a class of MCDA/MCDM. Since the past decades, MCDM has emerged as a subdiscipline or branch of operations research that focuses on creating mathematical and computational tools for supporting decision-making in subjective evaluation of a finite number of decision alternatives under a finitenumber of performance criteria [[16], [19], [14]]. To effectively navigate and evaluate/prioritize these criteria, the Analytical Hierarchy Process (AHP) which is one of the MADM tool is employed in this study to assists individuals in evaluating and comparing different criteria and alternatives in a hierarchical fashion. According to [31], the AHP approach simplifies a complex multi decision making process, makes it more systematic, and introduces transparency while saving cost and resources. The AHP can be applied to a multitude of decision-making problems involving a finite number of alternatives [5]. In the context of academic performance and graduating with/at maximum achievement, the AHP frame work can be valuable approach to identify, assess and prioritize the CSFs (criteria) that contribute to this goal. By using AHP, individuals can assign relative weights to these factors, enabling a more systematic and data-driven approach to decision making and goal setting.

3. CSFs for Graduating with Maximum Achievement

A number of factors have been identified in some research literature as being important for students to achieve success and high performance in HEIs. To make informed decisions, a set of diverse CSFs were gleaned from the literature. For example, factors responsible for students' academic success are found in [[4], [29], [7], [3], [23]], and those CSFs predictive for
students' high academic performance can be found in [[3], [33], [10], [13], [15]].

The identified CSFs were refined and synthesized to thirty-two (32) factors and then grouped into six different CFSs categories so that the final list reflects broadly six main CSFs that relate to a HEI studentship: - Behaviour towards academics, Hard work, Organization, Peers and Socials, Skills, and Studying Style or Pattern. These CSFs which are products from the above research studies intersect with different academic departments and disciplines as our focus is students-based or oriented. In other words, we are concern with identifying what factors can help a student in any department or discipline to attain Grade 'A' in table 1, in any university the world over. The results of this study is not restricted to departments or disciplines in universities or countries, but purports a global academic domain.

In the jargons of MADM, the category names represent the main-attributes (CSFs), and the factors grouped under particular category are called sub-attributes (CSFs). Figure 2 depicts the identified self-explanatory main-CSFs and sub-CSFs considered for decision making for graduating with/at maximum achievement, as summarized due to space limitations. As attributes play very key role in the MCDM decision-making process, their determination is very crucial [14]. The next section
presents the basics of the AHP.

4. Basics of Analytic Hierarchy Process (AHP)

The AHP approach was developed and introduced by Dr. Thomas L. Saaty to support decision-making problems with multiple criteria, [16]. [[25], [28]] defined AHP as a structured approach for dealing with complex decisions by breaking them down into a hierarchical structure of criteria and alternatives. Since then, the AHP has been a decision-making methodology used to prioritize and make choices among various alternatives by structuring complex problems into a hierarchical model. When it comes to graduating with maximum achievement in an educational context, identifying the critical success factors using AHP can be highly beneficial. The primary goal is to excel academically and achieve the highest possible grades. According to [[26], [27]], the AHP methodology comprises of three fundamental developmental stages, namely: structuring the problem in a hierarchy; performing comparative judgments between elements and decision alternatives, and priority analysis.

In a typical graduating top-of-the-scale situation, AHP starts by creating a hierarchical structure that breakdown the goal into its components thereby presenting the most important elements and their relations as presented in Figure 2. It showcases the functional interactions of the components and their impact towards realizing the goal, [9]. In the judgment phase, peer-to-peer comparison is carryout on all the criteria (CSFs) in a given level with the connected criteria (CSFs) in the level just above to which it is linked directly using Saaty's 9-point judgment scale that represents the intensity of a particular element over another [26].

On this scale of relative importance: 1 signifies equal degree of importance while 9 is complete importance. The nitty-gritty of the AHP algorithm for graduating with/at maximum achievement is fully explained in a stepwise fashion below.

In order to investigate the relative priorities of the CSFs (Criteria) for graduating top of the scale in HEI using AHP, we adopt the AHP methodology shown in Figure 1 below.

4.1. Development of AHP methodology for graduating with Maximum Achievement

In graduating with/at maximum achievement decision process, there is one goal (graduate with "A" grade) and a finite set of *alternatives*, $X = \{x_1, \cdots, x_n\}$ from which the decision maker (student), is expected to select the best combination. Since real-life problems come with various complexities, by AHP's strategy, the original problem is decomposed into many smaller subproblems, [27]. Figure 2 shows a four-level decision hierarchy. The basic elements of the Saaty's hierarchical model are the main objective or goal to achieve, the criteria that affect the overall goal, the sub-criteria that influence the main criteria and finally the alternatives available to the problem. By structuring the problem in this way, it is possible to better understand the decision to be achieved, the criteria to be used and the alternatives to be evaluated [30].

To obtain the degree of relative importance of factors at each level, a pair-wise comparison matrix is developed using Saaty 1-9 suggested preference scale [26] of numbers that indicates how many times more important or dominant one factor is over another factor with respect to the criterion to which they are compared. The eigenvector and the maximum eigenvalue ($\lambda_{\max}$) are then derived from the pair-wise comparison matrices. The importance of the eigenvalue is to determine the degree of the consistency ratio, CR, [27] of the comparative matrix in order to confirm whether the pair-wise comparison matrix provides a completely consistent assessment. Next step is to derive the consistency index (CI) Table 2 and consistency ratio (CR), and finally is to determine the global weights of each CSF, sub-CSF and Alternatives,[11].

To graduate with/at maximum achievement using AHP model we proceed according to the following seven major steps:

Step 1: Defining the goal/objectives

Step 2: Developing the AHP hierarchy by decomposing the goal into lower-level CSFs or sub-CSFs etc.

Step 3: Construct a set of pair-wise comparison matrices for each of the levels.

Step 4: Construct the weighted, normalized decision matrix.

Step 5: Check for consistency in the pair-wise comparison matrix to obtain, λ_{Max}.

Step 6: Compute the Consistency Index (CI) and Consistency Ratio (CR).

Step 7: Calculate the global weights of each CSF, sub-CSF and Alternatives.

Steps 3-6 are performed for purpose of ascertaining the relative importance of each CSF for all levels in the hierarchy. The detailed descriptions of each step follow:

Step 1. The goal or objective in our case is identified as: "To graduate with/at maximum achievement". The major-CSFs and sub-CSFs (or elements) considered for decision making to graduate with/at maximum achievement as well as the alternatives considered - Grade A, B, and C respectively are as presented in Figure 2.

Step 2. The goal is decomposed into 6 main-CSFs, 32 sub-CSFs and 3 Alternatives so as to form a hierarchical abstraction of the decision problem.as in figure 2. Here, the goal or objective is the first level, main-CSFs are in the second level, sub-CSFs are in third level, while the alternatives are at the last level. Here, Grade A, Grade B, and Grade C are considered Alternatives as they are usually conceivable in any HEI and since no student would potentially desire Grade 'F'. Most importantly, Grade 'B' and Grade 'C' were added to represent the worst-case scenarios of the goal. The AHP model is an optimization procedure that converges to the best alternative. In the language of optimization, they represent sub-optimal solutions as against the optimal, Grade 'A'. See Table 1.

Step 3. Construct a set of pair-wise comparison matrices for each of the levels.

From the hierarchical structure, any CSF in the higher level is a controlling CSF for those in the lower level, as it either influences it or contributes to it. The CSFs in the lower level are then compared to each other based on their influence on the controlling CSFs above. To determine the relative importance among the CSFs and sub-CSFs at each level we compare carefully CSFs of each hierarchy level by assigning Saaty's scale of relative importance (1-9), [27] in a pair-wise fashion with respect to the goal or objective of the model. The result of this collective or group decision of the authors gave birth to matrices of comparisons according to equation (1). These group's decision judgements were synthesized using Saaty's fundamental scale of absolute numbers, [27], not outlined here due to lack of space. Thus, with n CSFs, there will be $\frac{n(n-1)}{2}$ judgements required to develop a single pair-wise comparison matrix subject to equation (2) below, and the pairwise comparison of CSF j with CSF k produces a square matrix $A_{n\times n}$ of judgement, such that:

$$A_{n\times n} = \begin{matrix} Attributes \\ 1 \\ 2 \\ 3 \\ \vdots \\ n \end{matrix} \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

Subject to the constraints

$$a_{jj} = 1, a_{jk} > 0, a_{jk} = \frac{1}{a_{kj}}, \forall j, k = 1, 2, 3, \cdots, n \tag{2}$$

So, if the entries exactly represent ratios between weights and by the condition of multiplicative reciprocity in equation (2), then matrix A can be express as:

$$A = (\frac{w_j}{w_k})_{n\times n} = \begin{bmatrix} 1 & a_{12} & a_{13} & \cdots & a_{1n} \\ \frac{1}{a_{21}} & 1 & a_{23} & \cdots & a_{2n} \\ \frac{1}{a_{31}} & \frac{1}{a_{32}} & 1 & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a_{n1}} & \frac{1}{a_{n2}} & \frac{1}{a_{n3}} & \cdots & 1 \end{bmatrix} \tag{3}$$

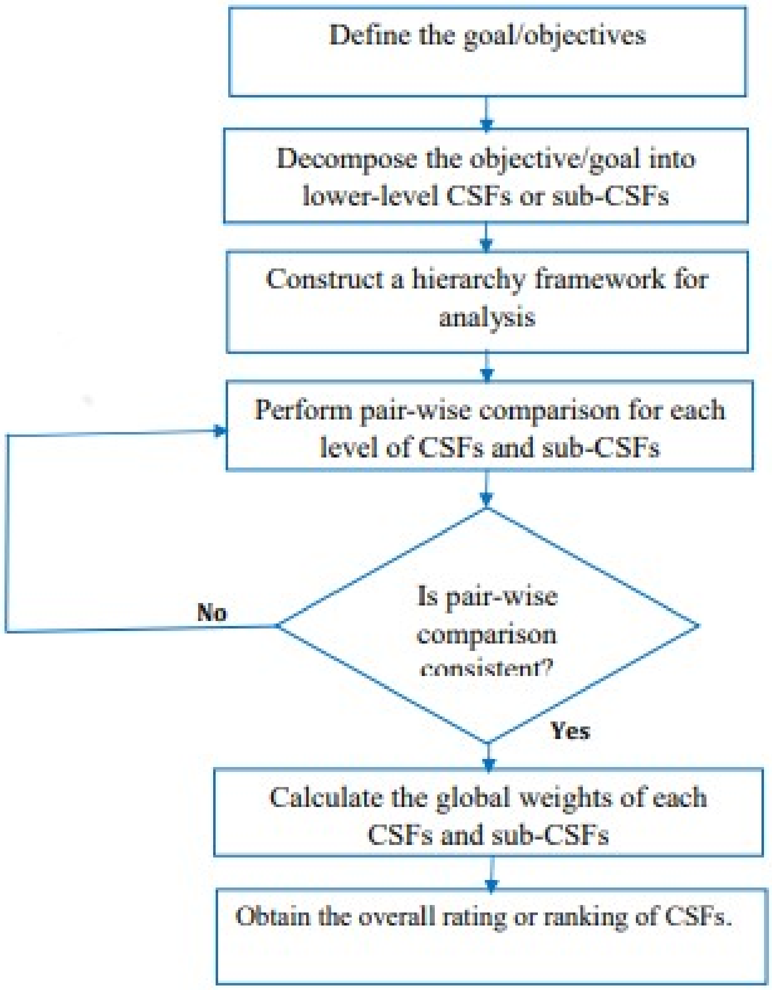

Figure 1: A Flow chart of AHP model for graduating with Maximum Achievement

where
a_{jk} denotes the comparative importance of attribute j with respect to attribute k. From Figure 2, there are 39 pairwise comparison matrices in all. Seven, i.e. One for the major CSFs; C_1 , C_2, C_3, C_4, C_5, and C_6 with respect to the goal (Level 1), which is shown in Table 3, (One 6 x 6), and six for the sub-CSFs with respect to the major-CSFs (Level 2, presented in Tables 4 - 9):- the first for the sub-CSF under C_1: C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16} and C_{17} shown in Table 4, (One 7 x 7); for the sub-CSF under C_2: C_{21}, C_{22}, C_{23}, C_{24}, C_{25} and C_{26} shown in Table 5, (One 6 x 6); for the sub-CSF under C_3: C_{31}, C_{32}, C_{33}, C_{34}, and C_{35} as shown in Table 6, (One 5 x 5); for the sub-CSF under C_4: C_{41}, C_{42}, and C_{43},that is shown in Table 7, (One 3 x 3); for the sub-CSF under C_5: C_{51}, C_{52}, C_{53}, C_{54}, C_{55} and C_{56} shown in Table 8 (One 6 x 6) , and for the sub-CSF under

C_6: C_{61}, C_{62}, C_{63}, C_{64} and C_{65} as shown in Table 9 (One 5 x 5). Next, there are 32

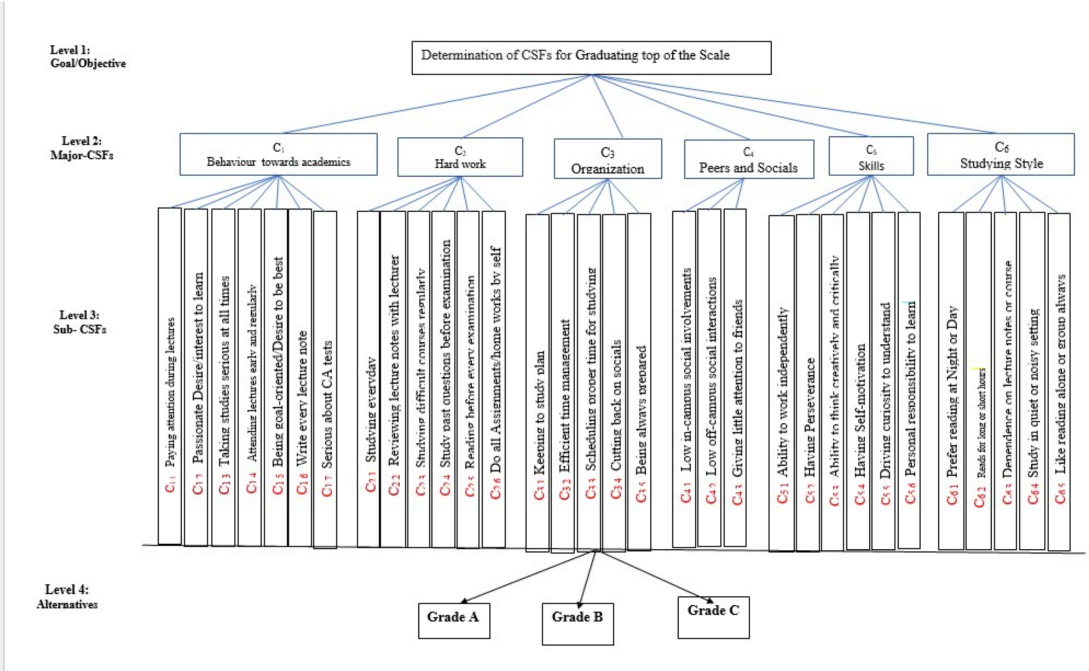

Figure 2: AHP model of CSFs for graduating with Maximum Achievement

comparison matrices for the three alternatives with respect to all the 'covering CSFs'- the lowest level CSFs or sub-CSFs connected to the alternatives. These 32 covering CSFs are: C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16} and C_{17}, (meaning Seven 3 x 3); C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, and C_{26}, (Six 3 x 3); C_{31}, C_{32}, C_{33}, C_{34} and C_{35}, (Five 3 x 3); C_{41}, C_{42}, and C_{43}, (Three 3 x 3); C_{51}, C_{52}, C_{53}, C_{54}, C_{55}, and C_{56}, (Six 3 x 3), and C_{61}, C_{62}, C_{63}, C_{64} and C_{65}, (Five 3 x 3). All are sub-CSFs in Level 3 and are shown in Table 10. **Tables 3 − 10** show the respective pair-wise comparison matrices along with their corresponding vector of priorities. A vector of priorities is the principal eigenvector of the matrix that gives the relative priority of the criteria measured on a ratio scale.

Step 4**:** Construct the weighted, normalized decision matrix

To obtain the Eigen values of the pair-wise comparison matrices, the matrix is first normalized by dividing each entry in column j by the sum of the entries in column j . This generates the normalized matrix in which the sum of the entries in each column is '1', see equation (4). Next, obtain the priority weights, also called the principal vector (PV) or Eigen value, by computing the average of the entries in row of the normalized matrix. Priority means the relative importance or strength of influence of a CSF in relation to other CSFs that are placed above it in the hierarchy, see equation (5).

$$C_{jk} = \frac{a_{jk}}{\sum\limits_{j=1}^{n} a_{jk}}, \forall j, k = 1, 2, 3, \cdots, n \tag{4}$$

Table 2: Average Randomly Generated Consistency Indexes (RGCI), [11]

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

$$w_j = \frac{\sum_{j=1}^{n} c_{jk}}{n}, \forall j, k = 1, 2, 3, \cdots, n, W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \tag{5}$$

Step 5: Check for consistency in the pair-wise comparison matrix to obtain, λ_{Max}
Since pair-wise comparison matrices are products of subjective judgements it is possible that the decision maker may be inconsistent in the judgements. To ensure that the judgments of decision makers are consistent, the AHP procedure incorporates this step into the model to examines whether the created pairs of matrices are consistent or not, and also provides the decision makers with a measure of the inconsistencies. To check for the consistency of judgements as presented in Tables 3 – 10, let the considered pair-wise comparison matrix be denoted as δ_1 and the corresponding column vector, PV be denoted as δ_2 , then compute the column δ and the column eigenvector λ as:

$$\delta = \delta_1 * \delta_2 \qquad \lambda_{Max} = \underset{\forall j,k}{Max}\left(\frac{\delta}{\delta_2}\right) = \underset{\forall j,k}{Max}\left(\frac{j^{th} \text{ entry in } \delta}{j^{th} \text{ entry in } \delta_2}\right) \tag{6}$$

Step 6: Compute the Consistency Index (CI) and Consistency Ratio (CR)
The CR is used to confirm whether a criterion (CSF) can be used for decision-making. It is obtained from the ratio of the consistency of the results being examined to the consistency of the same problem evaluated with a random number as:

$$CI = \frac{(\lambda_{Max} - n)}{(n-1)} \qquad CR = \frac{CI}{RGCI} \tag{7}$$

where n denotes the order of matrix and the Randomly Generated Consistency Index. If CI is sufficiently small, the decision maker's comparisons are significantly consistent enough to give useful estimates of the priority weights for the goal or objective. If $CR < 0.10$ (10%), the degree of consistency in the judgments is significantly acceptable, so the obtained weights can be used for decision making. However, if $CR > 0.10$, serious inconsistencies may exist, and the AHP may not yield meaningful results, so the assessment can be revised as indicated in Figureb1 above. Table 2 shows average Randomly Generated Consistency indexes (RGCI) of the matrices of order 1–15, [11].

Step 7: Calculate the global weights of each CSF, sub-CSF and Alternatives The priority weights (or Principal vectors (PVs)) are divided into 'local weights (LWs)' – the Eigen value or priority weight with respect to the preceding hierarchical level, and 'global weights (GWs)'– the Eigen value or priority weight with respect to the highest hierarchical level – the objective or goal. To carry out an overall ranking for sub-CSFs, AHP consolidates the priority weights of CSFs with the comparison rating for sub-CSFs and alternatives. That is, each Priority weight (PW) of the main CSF in level 2 (L2-PW) is multiplied by the respective PW value of sub-CSF in level 3 (L3-PW), which in turn is again multiplied by the PW value for each respective alternative (L4-PW) to get the desirability index (DI) of the alternative for each sub-CSF, using equation 8. Finally, the sum of the desirability indexes (DIs) obtained for each of the sub-criterion gives the overall DI for each alternative (Figure 3). The alternative with the highest DI is chosen or preferred [30].

$$[H]GW_s = \sum_{j,k=1}^{n} (LW \text{ for criterion } j \times LW \text{ for sub-criterion } k \text{ w.r.t. criterion } j) \tag{8}$$

4.2. Comparison Matrices and their Local priorities

Table 3: Pair-wise Comparison Matrix for the Goal Level 1

Goal	C_1	C_2	C_3	C_4	C_5	C_6	**Priority**
C1	1	0.2	0.5	0.25	2	4	**0.088**
C2	5	1	4	2	7	9	**0.418**
C3	2	0.25	1	0.5	4	5	**0.15**
C4	4	0.2	2	1	5	7	**0.256**
C5	0.5	0.14	0.25	0.2	1	2	**0.05**
C6	0.25	0.11	0.2	0.14	0.5	1	**0.032**
Sum	12.75	2.2	7.95	4.09	19.5	28	**1**
$\lambda_{Max} = 6.231$, $C.I. = 0.046$, $C.R. = 0.040$							

Table 4: Pair-wise Comparison Matrix for the Main CSF (C_1) Level 2

Sub-CSFs	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	**Priority**
C_{11}	1	0.25	0.1667	2	0.333	0.5	0.25	**0.05**
C_{12}	4	1	0.333	4	3	3	2	**0.205**
C_{13}	6	3	1	8	4	5	3	**0.387**
C_{14}	o.50	0.25	0.125	1	0.333	0.333	0.25	**0.094**
C_{15}	3	0.33	0.25	3	1	2	0.5	**0.105**
C_{16}	2	0.33	0.2	3	0.5	1	0.33	**0.075**
C_{17}	4	0.5	0.333	4	2	3	1	**0.159**
Sum	20.5	5.66	2.4077	22	11.166	14.833	7.33	**1**
$\lambda_{Max} = 8.400$, $C.I. = 0.123$, $C.R. = 0.090$								

Table 5: Pair-wise Comparison Matrix for the Main CSFs (C_2) Level 2

Sub-CSFs	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	**Priority**
C_{21}	1	0.2	0.5	0.25	2	4	**0.088**
C_{22}	5	1	4	2	7	9	**0.418**
C_{23}	2	0.25	1	0.5	4	5	**0.15**
C_{24}	4	0.2	2	1	5	7	**0.256**
C_{25}	0.5	0.14	0.25	0.2	1	2	**0.05**
C_{26}	0.25	0.11	0.2	0.14	0.5	1	**0.032**
Sum	12.75	2	7.95	4.09	19.5	28	**1**
$\lambda_{Max} = 6.231$, $C.I. = 0.046$, $C.R. = 0.030$							

Table 6: Pair-wise Comparison Matrix for the Main CSFs (C_3) Level 2

Sub-CSFs	C_{31}	C_{32}	C_{33}	C_{34}	C_{35}	**Priority**
C_{31}	1	2	3	4	5	**0.404**
C_{32}	0.5	1	2	4	5	**0.28**
C_{33}	0.33	0.5	1	3	2	**0.157**
C_{34}	0.25	0.25	0.33	1	3	**0.098**
C_{35}	0.2	0.2	0.5	0.33	1	**0.06**
Sum	2.28	3.95	6.83	12.33	16	**1**
$\lambda_{Max} = 5.374$, $C.I. = 0.094$, $C.R. = 0.080$						

Table 7: Pair-wise Comparison Matrix for the Main CSFs (C_4) Level 2

Sub-CSFs	C_{41}	C_{42}	C_{43}	**Priority**
C_{41}	1	5	4	**0.667**
C_{42}	0.2	1	0.33	**0.103**
C_{43}	0.25	3	1	**0.23**
Sum	1.45	9	5.33	**1**
$\lambda_{Max} = 3.014$, $C.I. = 0.007$, $C.R. = 0.010$				

Table 8: Pair-wise Comparison Matrix for the Main CSFs (C_5) Level 2

Sub-CSFs	C_{51}	C_{52}	C_{53}	C_{54}	C_{55}	**Priority**
C_{51}	1	2	3	4	5	**0.404**
C_{52}	0.5	1	2	4	5	**0.28**
C_{53}	0.33	0.5	1	3	2	**0.157**
C_{54}	0.25	0.25	0.33	1	3	**0.098**
C_{55}	0.2	0.2	0.5	0.33	1	**0.06**
Sum	2.28	3.95	6.83	12.33	16	**1**
$\lambda_{Max} = 6.230$, $C.I. = 0.046$, $C.R. = 0.040$						

Table 9: Pair-wise Comparison Matrix for the Main CSFs (C_6) Level 2

Sub-CSFs	C_{61}	C_{62}	C_{63}	C_{64}	C_{65}	**Priority**
C_{61}	1	2	3	4	5	**0.404**
C_{62}	0.5	1	2	4	5	**0.28**
C_{63}	0.33	0.5	1	3	2	**0.157**
C_{64}	0.25	0.25	0.33	1	3	**0.098**
C_{65}	0.2	0.2	0.5	0.33	1	**0.06**
Sum	2.28	3.95	6.83	12.33	16	**1**
$\lambda_{Max} = 5.374, \quad C.I. = 0.094, \quad C.R. = 0.090$						

Table 10: Pair-wise comparison matrix for Level 3

C_{11}	**A**	**B**	**C**	**Priority**		C_{12}	**A**	**B**	**C**	**Priority**
A	1	4	9	**0.701**		**A**	1	6	8	**0.739**
B	0.25	1	5	**0.231**		**B**	0.167	1	4	**0.192**
C	0.11	0.2	1	**0.068**		**C**	0.125	0.25	1	**0.069**
Sum	1.36	5.2	15	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.100, \quad C.I. = 0.050, \quad C.R. = 0.086$						$\lambda_{Max} = 3.083, \quad C.I. = 0.042, \quad C.R. = 0.070$				
C_{13}	**A**	**B**	**C**	**Priority**		C_{14}	**A**	**B**	**C**	**Priority**
A	1	4	9	**0.701**		**A**	1	6	8	**0.739**
B	0.25	1	5	**0.231**		**B**	0.167	1	4	**0.192**
C	0.11	3	1	**0.068**		**C**	0.125	0.25	1	**0.069**
Sum	1.36	5.2	15	**1**		**Sum**	1.45	5.33	9	**1**
$\lambda_{Max} = 3.101, \quad C.I. = 0.051, \quad C.R. = 0.090$						$\lambda_{Max} = 3.083, \quad C.I. = 0.042, \quad C.R. = 0.072$				
C_{15}	**A**	**B**	**C**	**Priority**		C_{16}	**A**	**B**	**C**	**Priority**
A	1	5	7	**0.724**		**A**	1	4	9	**0.701**
B	0.2	1	3	**0.193**		**B**	0.205	1	5	**0.231**
C	0.143	0.33	1	**0.083**		**C**	0.11	0.2	1	**0.068**
Sum	1.343	6.33	11	**1**		**Sum**	1.36	5.2	15	**1**
$\lambda_{Max} = 3.036, \quad C.I. = 0.018, \quad C.R. = 0.030$						$\lambda_{Max} = 3.100, \quad C.I. = 0.050, \quad C.R. = 0.090$				
C_{17}	**A**	**B**	**C**	**Priority**		C_{21}	**A**	**B**	**C**	**Priority**
A	1	6	8	**0.739**		**A**	1	5	7	**0.724**
B	0.167	1	4	**0.192**		**B**	0.2	1	3	**0.193**
C	0.125	0.25	1	**0.069**		**C**	0.143	0.33	1	**0.083**
Sum	1.292	7.259	13	**1**		**Sum**	1.343	6.33	11	**1**
$\lambda_{Max} = 3.083, \quad C.I. = 0.040, \quad C.R. = 0.070$						$\lambda_{Max} = 3.036, \quad C.I. = 0.020, \quad C.R. = 0.034$				
C_{22}	**A**	**B**	**C**	**Priority**		C_{23}	**A**	**B**	**C**	**Priority**
A	1	5	7	**0.724**		**A**	1	4	9	**0.726**
B	0.2	1	3	**0.193**		**B**	0.25	1	5	**0.209**
C	0.143	0.333	1	**0.083**		**C**	0.11	0.2	1	**0.065**
Sum	1.343	6.333	11	**1**		**Sum**	1.36	5.2	15	**1**
$\lambda_{Max} = 3.036, \quad C.I. = 0.018, \quad C.R. = 0.030$						$\lambda_{Max} = 3.100, \quad C.I. = 0.050, \quad C.R. = 0.090$				

Table 11: Continuation of Table 10 Pair-wise comparison matrix for Level 3

C_{24}	**A**	**B**	**C**	**Priority**		C_{25}	**A**	**B**	**C**	**Priority**
A	1	3	7	**0.657**		**A**	1	6	8	**0.739**
B	0.33	1	5	**0.274**		**B**	0.167	1	4	**0.192**
C	0.143	0.2	1	**0.069**		**C**	0.125	0.25	1	**0.069**
Sum	1.473	4.2	13	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.013$, $C.I. = 0.006$, $C.R. = 0.010$						$\lambda_{Max} = 3.083$, $C.I. = 0.041$, $C.R. = 0.072$				
C_{26}	**A**	**B**	**C**	**Priority**		$C + 31$	**A**	**B**	**C**	**Priority**
A	1	4	9	**0.701**		**A**	1	6	8	**0.739**
B	0.25	1	5	**0.231**		**B**	0.167	1	4	**0.192**
C	0.11	0.2	1	**0.068**		**C**	0.125	0.25	1	**0.069**
Sum	1.361	5.2	9	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.092$, $C.I. = 0.046$, $C.R. = 0.070$						$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.090$				
C_{32}	**A**	**B**	**C**	**Priority**		C_{33}	**A**	**B**	**C**	**Priority**
A	1	4	9	**0.701**		**A**	1	6	8	**0.739**
B	0.25	1	5	**0.231**		**B**	0.167	1	4	**0.192**
C	0.11	0.2	1	**0.068**		**C**	0.125	0.25	1	**0.069**
Sum	1.361	5.2	15	**1**		**Sum**	1.292	7.25	13..000	**1**
$\lambda + Max = 3.010$, $C.I. = 0.050$, $C.R. = 0.090$						$\lambda_{Max} = 3.083$, $C.I. = 0.042$, $C.R. = 0.070$				
C_{34}	**A**	**B**	**C**	**Priority**		C_{35}	**A**	**B**	**C**	**Priority**
A	1	6	8	**0.739**		**A**	1	5	7	**0.724**
B	0.167	1	4	**0.192**		**B**	0.2	1	3	**0.193**
C	0.125	0.25	1	**0.069**		**C**	0.143	0.333	1	**0.083**
Sum	1.292	7.25	13	**1**		**Sum**	1.343	6.333	11	**1**
$\lambda_{Max} = 3.083$, $C.I. = 0.042$, $C.R. = 0.070$						$\lambda_{Max} = 3.014$, $C.I. = 0.069$, $C.R. = 0.012$				
C_{41}	**A**	**B**	**C**	**Priority**		C_{42}	**A**	**B**	**C**	**Priority**
A	1	6	8	**0.739**		**A**	1	4	9	**0.535**
B	0.167	1	4	**0.192**		**B**	0.25	1	5	**0.285**
C	0.125	0.25	1	**0.069**		**C**	0.11	0.2	1	**0.18**
Sum	1.292	7.25	13	**1**		**Sum**	1.36	5.2	15	**1**
$\lambda_{Max} = 3.083$, $C.I. = 0.042$, $C.R. = 0.072$						$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.090$				
C_{43}	**A**	**B**	**C**	**Priority**		C_{51}	**A**	**B**	**C**	**Priority**
A	1	5	7	**0.724**		**A**	1	4	9	**0.701**
B	0.2	1	3	**0.193**		**B**	0.25	1	5	**0.231**
C	0.143	0.33	1	**0.083**		**C**	0.11	0.2	1	**0.068**
Sum	1.343	6.33	11	**1**		**Sum**	1.7	3.33	9	**1**
$\lambda_{Max} = 3.014$, $C.I. = 0.068$, $C.R. = 0.012$						$\lambda_{Max} = 3.100$, $C.I. = 0.051$, $C.R. = 0.086$				

Table 12: Continuation of Table 10 Pair-wise comparison matrix for Level 3

C_{52}	**A**	**B**	**C**	**Priority**		C_{53}	**A**	**B**	**C**	**Priority**
A	1	6	8	**0.739**		**A**	1	6	8	**0.739**
B	0.167	1	4	**0.192**		**B**	0.167	1	4	**0.192**
C	0.125	0.25	1	**0.069**		**C**	0.125	0.25	1	**0.069**
Sum	1.292	7.25	13	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.090$						$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.086$				
C_{54}	**A**	**B**	**C**	**Priority**		C_{55}	**A**	**B**	**C**	**Priority**
A	1	4	9	**0.701**		**A**	1	6	8	**0.739**
B	0.25	1	5	**0.231**		**B**	0.167	1	4	**0.192**
C	0.11	0.2	1	**0.068**		**C**	0.125	0.25	1	**0.069**
Sum	1.36	5.2	15	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.086$						$\lambda_{Max} = 3.083$, $C.I. = 0.042$, $C.R. = 0.072$				
C_{56}	**A**	**B**	**C**	**Priority**		C_{61}	**A**	**B**	**C**	**Priority**
A	1	6	8	**0.571**		**A**	0.167	6	8	**0.739**
B	0.167	1	4	**0.286**		**B**	0.125	1	4	**0.192**
C	0.125	0.25	1	**0.143**		**C**	0.25	0.25	1	**0.069**
Sum	1.292	7.25	7.1	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.080$, $C.I. = 0.042$, $C.R. = 0.072$						$\lambda_{Max} = 3.083$, $C.I. = 0.042$, $C.R. = 0.072$				
C_{62}	**A**	**B**	**C**	**Priority**		C_{63}	**A**	**B**	**C**	**Priority**
A	1	5	7	**0.724**		**A**	1	4	9	**0.701**
B	0.2	1	3	**0.193**		**B**	0.25	1	5	**0.231**
C	0.143	0.33	1	**0.083**		**C**	0.11	0.2	1	**0.068**
Sum	1.343	6.33	11	**1**		**Sum**	1.36	5.2	15	**1**
$\lambda_{Max} = 3.036$, $C.I. = 0.020$, $C.R. = 0.030$						$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.090$				
C_{64}	**A**	**B**	**C**	**Priority**		C_{65}	**A**	**B**	**C**	**Priority**
A	1	4	9	**0.701**		**A**	1	6	8	**0.739**
B	0.25	1	5	**0.231**		**B**	0.167	1	4	**0.192**
C	0.11	0.2	1	**0.068**		**C**	0.125	0.25	1	**0.069**
Sum	1.36	5.2	15	**1**		**Sum**	1.292	7.25	13	**1**
$\lambda_{Max} = 3.100$, $C.I. = 0.050$, $C.R. = 0.090$						$\lambda_{Max} = 3.082$, $C.I. = 0.041$, $C.R. = 0.072$				

5. Results, Analysis and discussions

5.1. Level 2 towards achieving the Goal (Level 1)

Analysis of the pair-wise comparison matrix (Table 3) identified C_2 (Hard work) with the highest $PV = 0.418$ as the major CSF to achieve the goal of graduating at the top in

LWs of CSFs (L2)	LWs of Sub-CSFs (L3)	LWs of Alternatives (L4)	GWs (PVs) of Alternatives (L4)	GWs for CSFs / Desirability index for Alternatives		
				A	B	C
WC1 = 0.088	WC1 1 = 0.050	WA= 0.701 WB= 0.211 WC= 0.062	0.088 *0.050 * 0.701 0.088 * 0.050 * 0211 0.088 * 0.050 * 0.062	0.0031	0.0009	0.0003
	WC1 2 = 0.205	WA= 0.739 WB= 0.112 WC= 0.069	0.088 * 0.205 * 0.739 0.088 * 0.205 * 0.112 0.088 * 0.205 * 0.069	0.0133	0.0020	0.0012
	WC1 3 = 0.387	WA= 0.701 WB= 0.211 WC= 0.062	0.088 * 0.387 * 0.701 0.088 * 0.387 * 0.211 0.088 * 0.387 * 0.062	0.0239	0.0072	0.0021
	WC1 4 = 0.094	WA= 0.074 WB= 0.192 WC= 0.069	0.088 * 0.094 * 0.739 0.088 * 0.094 * 0.192 0.088 * 0.094 * 0.069	0.0061	0.0016	0.0006
	WC1 5 = 0.105	WA= 0.724 WB= 0.193 WC= 0.083	0.088 * 0.105 * 0.724 0.088 * 0.105 * 0.193 0.088 * 0.105 * 0.083	0.0067	0.0018	0.0008
	WC1 6 = 0.075	WA= 0.701 WB= 0.211 WC= 0.062	0.088 * 0.075 * 0.701 0.088 * 0.075 * 0.211 0.088 * 0.075 * 0.062	0.0046.	0.0014	0.0004
	WC17 = 0.159	WA= 0.739 WB= 0.192 WC= 0.069	0.088 * 0.159 * 0.739 0.088 * 0.159 * 0.192 0.088 * 0.159 * 0.069	0.0103	0.0027	0.0010
WC2 = 0.418	WC2 1 = 0.088	WA= 0.724 WB= 0.193 WC= 0.083	0.418 * 0.088 * 0.724 0.418* 0.088 * 0.193 0.418 * 0.088 * 0.083	0.0266	0.0071	0.0031
	WC2 2 = 0.418	WA= 0.724 WB= 0.193 WC= 0.082	0.418 * 0.418 * 0.724 0.418 * 0.418 * 0.193 0. 418 * 0.418 * 0.082	0.1265	0.0337	0.0143
	WC2 3 = 0.150	WA= 0.726 WB= 0.242 WC= 0.065	0.418 * 0.150 * 0.726 0.418 * 0.150 * 0.242 0.418 * 0.150 * 0.065	0.0455	0.0152	0.0041
	WC2 4 = 0.256	WA= 0.607 WB= 0.270 WC= 0.069	0.418 * 0.256 * 0.607 0.418 * 0.256 * 0.270 0. 418 * 0.256 * 0.069	0.0650	0.0289	0.0074
	WC2 5 = 0.050	WA= 0.739 WB= 0.192 WC= 0.069	0.418 * 0.050 * 0.739 0.418 * 0.050 * 0.192 0.418 * 0.050 * 0.069	0.0154	0.0040	0.0014
	WC2 6 = 0.032	WA= 0.701 WB= 0.211 WC= 0.062	0.418 * 0.032 * 0.701 0.418 * 0.032 * 0.211 0.418 * 0.032 * 0.062	0.0094	0.0280	0.0008

Figure 3: Data summary of the complete CSFs analysis

school.

5.2. Level 3 towards achieving the Main CSFs (Level 2)

The following Sub-CSFs were identified as being crucial to achieving the goal of graduating top of the scale: C_{13} (Taking studies serious at all times), having the highest $PV = 0.387$ confirms that students must take their academic studies serious at all times. C_{22} (Reviewing lecture notes with lecturer), having the highest $PV = 0.418$ advices students to always review their lecture notes on each course with their course lecturer to prepare well for their test and exam to graduate at the top. C_{31} (Keeping to study plan) having the highest $PV = 0.404$ as one of the key sub-CSFs for graduating top. C_{41} (low in-campus social involvement) having the highest $PV = 0.667$ advices to keep a low in-campus social involvement. C_{51} (Ability to work independently) with the highest $PV = 0.404$ calls for self-reliance in achieving a goal. C_{61} (Prefer reading at Night or Day) with the highest $PV = 0.404$ advices students to choose comfortable time to read as

$WC_3 = 0.150$	$WC_{31} = 0.404$	WA= 0.739 WB= 0.192 WC= 0.069	0.150 * 0.404 * 0.739 0.150 * 0.404 * 0.192 0.150 * 0.404 * 0.069	0.0448	0.0117	0.0042
	$WC_{32} = 0.280$	WA= 0.701 WB= 0.211 WC= 0.062	0.150 * 0.280 * 0.701 0.150 * 0.280 * 0.211 0.150 * 0.280 * 0.062	0.0294	0.0089	0.0026
	$WC_{33} = 0.157$	WA= 0.739 WB= 0.192 WC= 0.069	0.150 * 0.157 * 0.738 0.150 * 0.157 * 0.192 0.150 * 0.157 * 0.069	0.0170	0.0045	0.0016
	$WC_{34} = 0.098$	WA= 0.739 WB= 0.192 WC= 0.069	0.150 * 0.098 * 0.739 0.150 * 0.098 * 0.192 0.150 * 0.098 * 0.069	0.0109	0.0028	0.0010
	$WC_{35} = 0.060$	WA= 0.724 WB= 0.193 WC= 0.083	0.150 * 0.060 * 0.724 0.150 * 0.060 * 0.193 0.150 * 0.060 * 0.083	0.0065	0.0017	0.0007
$WC_4 = 0.256$	$WC_{41} = 0.667$	WA= 0.739 WB= 0.192 WC= 0.069	0.256 * 0.667 * 0.739 0.256 * 0.667 * 0.192 0.256 * 0.667 * 0.069	0.1262	0.0328	0.0118
	$WC_{42} = 0.103$	WA= 0.701 WB= 0.211 WC= 0.062	0.256 * 0.103 * 0.701 0.256 * 0.103 * 0.211 0.256 * 0.103 * 0.062	0.0185	0.0056	0.0016
	$WC_{43} = 0.230$	WA= 0.724 WB= 0.192 WC= 0.083	0.256 * 0.23 * 0.724 0.256 * 0.23 * 0.192 0.256 * 0.23 * 0.083	0.0426	0.0113	0.0049
$WC_5 = 0.050$	$WC_{51} = 0.088$	WA= 0.701 WB= 0.211 WC= 0.062	0.050 * 0.088 * 0.701 0.050 * 0.088 * 0.211 0.050 * 0.088 * 0.062	0.0031	0.0009	0.0003
	$WC_{52} = 0.418$	WA= 0.739 WB= 0.192 WC= 0.069	0.050 * 0.418* 0.739 0.050 * 0.418 * 0.192 0.050 * 0.418 * 0.069	0.0154	0.0040	0.0014
	$WC_{53} = 0.150$	WA= 0.739 WB= 0.192 WC= 0.069	0.050 * 0.150 * 0.739 0.050 * 0.150 * 0.192 0.050 * 0.150 * 0.069	0.0055	0.0014	0.0005
	$WC_{54} = 0.256$	WA= 0.701 WB= 0.211 WC= 0.062	0.050 * 0.256 * 0.701 0.050 * 0.256 * 0.211 0.050 * 0.256 * 0.062	0.0090	0.0027	0.0008
	$WC_{55} = 0.050$	WA= 0.739 WB= 0.192 WC= 0.069	0.050 * 0.050 * 0.739 0.050 * 0.050 * 0.192 0.050 * 0.050 * 0.069	0.0020	0.0005	0.0002
	$WC_{56} = 0.032$	WA= 0.739 WB= 0.192 WC= 0.069	0.050 * 0.032 * 0.739 0.050 * 0.032 * 0.192 0.050 * 0.032 * 0.069	0.0012	0.0003	- 0.0001
$WC_6 = 0.032$	$WC_{61} = 0.404$	WA= 0.739 WB= 0.192 WC= 0.069	0.032 * 0.404 * 0.739 0.032 * 0.404 * 0.192 0.032 * 0.404 * 0.069	0.0096	0.0025	0.0009
	$WC_{62} = 0.280$	WA= 0.724 WB= 0.193 WC= 0.083	0.032 * 0.280 * 0.724 0.032 * 0.280 * 0.193 0.032 * 0.280 * 0.083	0.0065	0.0017	0.0007
	$WC_{63} = 0.157$	WA= 0.701 WB= 0.211 WC= 0.062	0.032 * 0.157 * 0.701 0.032 * 0.157 * 0.211 0.032 * 0.157 * 0.062	0.0035	0.0011	- 0.0003
	$WC_{64} = 0.098$	WA= 0.701 WB= 0.211 WC= 0.062	0.032 * 0.098 * 0.701 0.032 * 0.098 * 0.211 0.032 * 0.098 * 0.062	0.0022	0.0007	0.0002
	$WC_{65} = 0.060$	WA= 0.739 WB= 0.192 WC= 0.069	0.032 * 0.060 * 0.739 0.032 * 0.060 * 0.192 0.032 * 0.060 * 0.069	0.0014	0.0004	0.0001
SUM /OVERALL DESIRABILITY INDEX				0.9268	0.2048	0.0714

Figure 4: Continuation of Figure 3:Data summary of the complete CSFs analysis

their choice to perform well in their academics.

5.3. Level 4 towards achieving the Desired Alternative

To obtain Grade A (highest $PV = 0.701$), pay attention during lectures (C_{11}). To obtain Grade A (highest $PV = 0.739$), you must possess a Passionate Desire/interest to learn (C_{12}). To obtain Grade A (highest $PV = 0.701$), take studies serious at all times (C_{13}). Attending lectures early and regularly (C_{14}) will lead to achieving Grade A ($PV = 0.739$). Being goal – Oriented (C_{15}) will lead to achieving Grade A ($PV = 0.722$).

Taking every lecture note (C_{16}) will lead to achieving Grade A ($PV = 0.701$). Being serious about CA tests (C_{17})) will lead to achieving Grade A ($PV = 0.7039$). Studying every day (C_{21}) will lead to achieving Grade A ($PV = 0.724$). Reviewing lecture note with lecturer (C_{22}) will lead to achieving Grade A ($PV = 0.724$). Studying difficult courses regularly (C_{23}) will lead to achieving Grade A ($PV = 0.726$). Studying past question before exam (C_{24}) will lead to achieving Grade A ($PV = 0.607$). Reading before every exam (C_{25}) will lead to achieving Grade A ($PV = 0.739$). Doing all Assignments/home works by oneself (C_{26}) will lead to achieving Grade A ($PV = 0.726$). Keeping to study plan (C_{31}) will lead to achieving Grade A ($PV = 0.739$). Efficient time management (C_{32}) will lead to achieving Grade A ($PV = 0.701$). Scheduling proper time for studying (C_{33}) will lead to achieving Grade A ($PV = 0.739$). Cutting back on socials (C_{34}) will lead to achieving Grade A ($PV = 0.739$). Being always prepared (C_{35}) will lead to achieving Grade A ($PV = 0.724$). Low in - campus social environment (C_{41}) will lead to achieving Grade A ($PV = 0.739$). Low off - campus social environment (C_{42}) will lead to achieving Grade A ($PV = 0.701$). Giving little attention to friends (C_{43}) will lead to achieving Grade A ($PV = 0.724$). Ability to work independently (C_{51}) will lead to achieving Grade A ($PV = 0.701$). Having Perseverance (C_{52}) will lead to achieving Grade A ($PV = 0.739$). Ability to think creatively and critically (C_{53}) will lead to achieving Grade A ($PV = 0.739$). Having self-motivation (C_{54}) will lead to achieving Grade A ($PV = 0.701$). Having a driving Curiosity to understand (C_{55}) will lead to achieving Grade A ($PV = 0.739$). A personal responsibility to learn (C_{56}) will lead to achieving Grade A ($PV = 0.739$). Preferring reading at Night or Day (C_{61}) will lead to achieving Grade A ($PV = 0.739$). Reading for long or short hours (C_{62}) will lead to achieving Grade A ($PV = 0.724$). Dependence on lecture notes or course materials (C_{63}) will lead to achieving Grade A ($PV = 0.701$). Study in quiet or noisy setting (C_{64}) will lead to achieving Grade A ($PV = 0.701$). Like reading alone or group always (C_{65}) will lead to achieving Grade A ($PV = 0.739$).
Tables $3 - 10$ will help the students (readers) understand the importance of each major CSF and sub-CSF. For instance, in Table 5, the PV/Eigen vector depicts the importance (Ranking) of each major CSF with respect to the goal. In this case, concern is about students' Hard work (C_2) as a key factor to graduating top with an A grade having the highest PV value. Similarly, Table 10 establishes the relative importance (Rankings) of the sub-CSFs and alternatives (Grade **A**, Grade **B** and Grade **C**) within the main-CSFs and are interpreted same accordingly with their respective PV values. The results of the AHP in Table 11 reveal that Grade **A** is achievable, as the overall desirability index (**0.9268**) is higher when compared to the rest of the alternatives.

6. Conclusions

Graduating with maximum achievement($GradeA = 80\% - 100\%$) can never be less important or overemphasized. This work has made a serious and solemn attempt to show the validity of the application of an MCDM tool, the AHP for modelling one of the strategic decisions in an important function of the educational system – namely, academic achievement and performance towards graduating with/at maximum achievement. A literature review on academic achievement and performance was carried out to provide an overview of the CSFs pivotal for higher grades achievements apart from highlighting the differences between them. Later, various research gaps were also identified. The application of AHP serves to re-awaken the awareness about the importance of high grades by distilling a subset of key independent variables called CSFs from an academic perspective, for students to graduate with/at maximum achievement in HEIs. By systematically evaluating and prioritizing CSFs such as behaviour towards academics, hard work, organization, peers and socials, skills and studying style or pattern, individuals can optimize their academic performance. Ultimately, the results of integrating AHP into educational strategies provide a structured framework for decision-making, enabling students to focus on the most impactful factors and tailor their efforts towards achieving academic excellence hence, enhancing their chances of graduating with/at maximum achievement. This paper provides a comparative analysis of findings with a view to identifying potential common Success factors, which could form the basis for future generalization. It is hoped that the results from this study will assist researchers and post-secondary personnel in better understanding the important factors for student success and provide the framework for further in-depth exploration. By employing AHP, we aim to provide a comprehensive understanding of the key factors that will enable students to excel academically and graduate with distinction.

Acknowledgements

The authors thank the readers of European Journal of Pure and Applied Mathematics, for making our journal successful.

References

[1] O. Alaskari, M. M. Ahmad, N. Dhafr, and R. Pinedo-Cuenca. Critical Successful Factors (CSFs) for Successful Implementation of Lean Tools and ERP Systems. *Proceedings of the World Congress on Engineering*, 3(2012):1–6, 2012.

[2] M. Alrasheedi and L. F. Capretz. Determination of Critical Success Factors Affecting Mobile Learning: A Meta-Analysis Approach. *The Turkish Online Journal of Educational Technology*, 14(2):41–51, 2015.

[3] D. Apple, W. Duncan, and W. Ellis. Key Learner Characteristics for Academic Success. *International Journal of Process Education*, 8(2):61–82, 2016.

[4] S. Bain, L. Fedynich, and M. Knight. The successful graduate student: a review of the factors for success. *Journal of Academic and Business Ethics*, 3(7):1–9, 2010.

[5] M. Brunelli. *Introduction to the Analytic Hierarchy Process.* Springer, New York, 2015.

[6] F. M. Dahlan and A. Zainuddin. Establishment of Critical Success Factors for Organizations Managing High-rise Residential Buildings: A Review. *International Journal of Academic Research in Business and Social Sciences*, 8(2):750–759, 2018.

[7] L. Fedynich, S. F. Bain, and M. E. Martinez. Faculty Perspectives on Graduate Student Success. *International Journal of Organizational Behavior in Education*, 4(1):1–7, 2016.

[8] L. P. Gates. Strategic planning with critical success factors and future scenarios: An integrated strategic planning framework. Technical Report November, 2010, CMU, 2010.

[9] A. Gurumurthy and R. Kodali. An application of analytic hierarchy process for the selection of a methodology to improve the product development process. *Journal of Modelling in Management*, 7(1):97–121, 2012.

[10] N. Hirzallah, D. Al-Halabi, and B. Al-Hamadani. University Grades System Application using Dynamic Data Structure. *IJCSI International Journal of Computer Science Issues*, 8(1):176–181, 2011.

[11] A. T. Ibraheem and N. S. Atia. Applying Decision Making with Analytic Hierarchy Process (AHP) for Maintenance Strategy Selection of Flexible Pavement. *Global Journal of Researches in Engineering (E)*, 16(5):25–34, 2016.

[12] K. Ismail, Y. R. Leow, I. Abdul-Majid C. Y. Yong, W. D. Thwala, and M. A. Ajagbe. Critical success factors of new product development in technology-based firms: A case study. . *African Journal of Business Management*, 6(33):9442–9451, 2012.

[13] V. Iva and K. Eliška. Flexible Graduate is Successful Graduate: Key Factors of Successful Job Interview, Results of a Comparative Analysis. *Journal of Competitiveness*, 8(2):87–102, 2016.

[14] R. Karim and C. L. Karmaker. Machine Selection by AHP and TOPSIS Methods. *American Journal of Industrial Engineering*, 4(1):7–13, 2016.

[15] G. D. Kuh, J. Kinzie, J. A. Buckley, B. K. Bridges, and J. C. Hayek. What matters to student success: A review of the literature. Technical Report 2006, Commissioned Report for the National Symposium on Postsecondary Student Success: Spearheading a Dialog on Student Success, National Postsecondary Education Cooperative (NPEC), 2006.

[16] A. A. Longaray, J. D. D. R. Gois, , and P. R. D. S. Munhoz. Proposal for using AHP method to evaluate the quality of services provided by outsourced companies. *Procedia Computer Science*, 55(2015):715–724, 2015.

[17] U. B. Man. *Identifying Critical Success Factors for School Improvement among Excellent Principals in High Performing Schools in Malaysia: A Case Study.* PhD thesis, Institute of Educational Leadership, Faculty of Education, University of Malaya, Kuala Lumpur,, 2018.

[18] C. H. Marcinkevage. *Critical Success Factors of Constituent Relationship Management (CRM) Strategy in a Higher Education Institution.* PhD thesis, Workforce Education and Development, The Graduate School, The Pennsylvania State University,, 2020.

[19] A. Mardani, A. Jusoh, and E. K. Zavadskas. Fuzzy multiple criteria decision-making techniques and applications–Two decades review from 1994 to 2014. *Expert Systems with Applications*, 42(2015):4126–4148, 2014.

[20] P. Nagy. Critical success factors: Measures of institutional effectiveness. Technical Report Seventh, Hillsborough Community College,Hillsborough County, Florida, 2012.

[21] C. M. Olszak and E. Ziemba. Critical Success Factors for Implementing Business Intelligence Systems in Small and Medium Enterprises on the Example of Upper Silesia, Poland. *Interdisciplinary Journal of Information, Knowledge, and Management*, 7(2012):129–150, 2012.

[22] P. C. F. Osorio, O. L. G. Quelhas, L. P. Zotes, E. Shimoda, and S. França. Critical Success Factors in Project Management: An Exploratory Study of an Energy Company in Brazil. *Global Journal of Management and Business Research: A*, 14(10):39–50, 2014.

[23] J. Ram and D. Corkindale. How critical are the critical success factors (CSFs)? Examining the role of CSFs for ERP. *Business Process Management Journal*, 20(1):151–174, 2014.

[24] J. F. Rockart. "Chief executives define their own data needs". *Harvard Business Review*, 57(2):81–93, 1979.

[25] T. L. Saaty. *The analytic hierarchy process.* McGraw- Hill, New York, 1980.

[26] T. L. Saaty. How to make a decision: The Analytic Hierarchy Process. *European Journal of Operational Research*, 48(1):9–26, 1990.

[27] T. L. Saaty. Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, 1(1):83–98, 2008.

[28] T. L. Saaty and L. G. Vargas. Models, methods, concepts & applications of the analytic hierarchy process. In Frederick S. Hillier, editor, *International Series in Operations Research & Management Science.*, volume 175. Springer, New York, USA, 2012.

[29] A. M. Stelnicki, D. W. Nordstokke, and D. H. Saklofske. Who is the successful university student? an analysis of personal resources. *Canadian Journal of Higher Education (CJHE)/Revue canadienne d'enseignement supérieur (RCES*, 45(2):214–228, 2015.

[30] F. Talib, Z. Rahman, and M. N. Qureshi. Prioritizing the practices of total quality management: An analytic hierarchy process analysis for the service industries. *Total Quality Management & Business Excellence*, 22(12):1331–1351, 2011.

[31] N. A. M. Yusof and S. H. Salleh. Analytical Hierarchy Process in Multiple Decisions Making for Higher Education in Malaysia. . *Procedia - Social and Behavioral Sciences*, 81(2013):389–394, 2013.

[32] N. Zakuan, S. Muniandy, M. Z. M. Saman, M. S. Md-Ariff, S.Sulaiman, and R. Abd-Jalil. Critical Success Factors of Total Quality Management Implementation in Higher Education Institution: A Review. *International Journal of Academic Research in Business and Social Sciences*, 2(12):19–32, 2012.

[33] A. Zhang and C. L. Aasheim. Academic Success Factors: An IT Student Perspective. *Journal of Information Technology Education*, 10(2011):309–331, 2011.