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Education Process Re-engineering through Spectral Pyramid Framework to Achieve Excellence in Engineering Education

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***Abstract*—** The Global challenges are capturing the interest and focus of Indian Higher Education institutions to update their systems and appraise the criteria of rankings. And it is difficult to justify the Indian Higher education institutions' unique excellence parameters and its scalability to meet the criteria of rankings, because of its diversity in institutions' size, nature of courses, disciplines, population, etc. Initially, the local challenges for Indian graduates which include appropriate employment, Career in further Studies, Entrepreneurship opportunities, etc. do not have a unique framework. The other focus area is lack of awareness and expertise in mezzanine technologies like Deep Learning, Artificial Intelligence, Renewable energy, Agricultural Technologies, Machine Learning, Data Science, Block Chain Technologies, Cyber Security, IoT, Virtual Reality, 3D Printing, Robotics, Design Thinking, etc. This paper has focused on these issues to collect the processes and designing a unique framework model to be adapted by higher educational institutions especially technical institutions in India. As the number of technical institutions is rising year on year, the demand is primarily dependent on quality and excellence outcomes. The proposed model is tested with current higher educational functions by implementing it in two higher educational institutions. The results are adaptable and applicable to any of technical higher education institution who are seeking excellence in processes.

***Keywords*—** Higher Education, Reengineering, Spectral Pyramid, Total Quality Management.

I. INTRODUCTION

BEFORE the beginning of industrialization, education was the privilege to the people of ancient times to learn better living systems with suitable skill set. In the present Indian context, the education system comprises of primary, secondary, senior secondary and higher education. And it is carried out by a combo in the mode of "career and education". But the glitches that are being faced by the institutions and graduates are majorly regarding the aspects of survival and goal attainment. Most of the existing processes in higher education are challenging the value and purpose of education for survival.

The ***'processes'*** in any educational institutions are immense at all levels and repeatable due to policy decisions and systems. To address the issues of processes, mainly focusing in higher education, the institutions are required to rethink and restructure the processes to improve its performance in line with business organizations. Hence, the major challenge is to face new demands from Industry & Society which requires technical educational institutions to be more agile and adaptable. The solution to face this challenge is to focus on the new dimensions imposed by emerging environmental and societal issues on education institutions in training manpower to meet the Local and Global Challenges.

Today academic institutions realized the importance of working in line with industries to get the benefits like knowledge of changing needs, competence analysis, taking shift from academic models to corporate models, quality placements and productive work environment. In this consequence, it is imperative to focus on processes of any educational institution towards quality and effectiveness to meet the best rankings.

The idea is to address the above issues related to Higher Education institution and illustrate the advantage of 'Education Processes' which are multipliable and repeatable. This research is focused to justify the value and order of 'processes' and how EPR methodology and an intervention can help to correct the situation to cater industrial and societal needs. Hence concept of 'Process Reengineering' has emerged as a solution and the necessity of Reengineering in education sector. And the framework of EPR methodology is represented graphically with a famous pyramid structure and named as "Spectral Pyramid". This model is created with major functions of education and management. To check its validity, it was implemented and tested with a research design and presented as a case study. The fallout of this can be used as a standard methodology which is adaptable and pervasive for any higher education institutions.

II. EPR ORIGIN AND UPBRINGING

The source of "Education Process Reengineering (EPR)" has arisen from business industry termed as "Business Process Reengineering (BPR)". Process Reengineering has grown by a variety of other terms, such as Restructuring, Transformation, Organizational Redesign, etc. Prof. Michael Hammer, a former professor of Computer Science at MIT in his one of the books has coined the name and is called as initial innovator and practitioner of this concept from 1991 onwards. Conferring to his definition as reengineering processes from top to bottom level, requires on or after scratch in making elementary hypothesis, to reject much of the conventional perceptions in any organization, and to "think out of box" to initiate changes through innovation.[1] Competitiveness due to Globalization & IT penetration in every domain required business processes to

be modified frequently towards standardization to Global levels. BPR provides "Fundamental rethinking and radical redesign of processes for dramatic improvement in overall performances".

The expansion of the BPR tool has extended to education sector from 1993 onwards in different forms to establish relationship between industry and academia. To highlight the major concern of adopting this tool in education sector, Prof. William Massy, et.al.(1994) pointed out, many academics would contend that academic process is of a fundamentally different order from business process: it resists business models of productivity of a Higher education institution.[2] For this reason, James Porter argues this should be applied only to administrative processes, namely the support processes that are the business-like side of higher education.[3] Prof. Stahlke, presented an alternative, arguing that reengineering must begin with teaching and learning, and those administrative changes should be driven by the results of academic reengineering.[4]

From various researchers, major objectives for adapting BPR tool for any business organization of manufacturing or service sector are to increase product quality, reduce production costs, increase speed in processes, improve customer satisfaction & achieve high profits.[5] To expand the adaptation into education sector, EPR objectives were recognized and compared with existing BPR objectives as increasing quality of graduates, improve cost-effectiveness, ensure process time to value, enhance societal impact, finally achieve scalability & rankings. These objectives were identified based on the current requirements of higher education institutions in India.

III. UNIQUE EPR ARCHITECTURE WITH SPECTRAL PYRAMID

The goal of any educational institution is to enlighten the learners by providing an arena to own their latest skills and reach higher platforms through innovation. The goal of education is advancement of knowledge and dissemination of truth. To reach this zenith, a famous pyramid structure is adapted and named as "EPR Spectral Pyramid" to build the unique model framework for EPR methodology. The specific reason to adapt pyramid structure is eternal mystery as fascinated archaeologists, engineers, mathematicians, geologists, physicist, chemists, astronomers and many more for various reasons. Still it inspires many to explore latent mysteries it carries in its womb. The amazing and accurate alignment of pyramid depicts the research and stands as testimony for the fact that has built as meticulous record keepers. And it offers inspiration, stimulation, valuable knowledge and an insight into organization structure. For any organization, it is possible to advance step by step slowly with mammoth efforts to live into excellence up to the pyramid towards their goal.

This architecture is presented in four phases, as (1) Functional Phase with Primary Elements (2) Decks Phase with a hierarchy of administration, (3) Building Blocks Phase with Process Groups, and (4) Tiles Phase with detailed processes. This model also supports the software construction to build and use the framework for the purpose of stakeholders.

A. Functional Phase(Primary Elements):

To develop an integrated framework of EPR, it is aimed to enhance the current academics to the next level research, innovation, entrepreneurship & to have social impact. Hence, the following four functions have identified and also colored as blue, magenta, purple and green along with pyramid sides which implies on all bricks to the bottom of the pyramid.

B. Decks Phase with hierarchy of administration

As the above four functions are represented by the four sides of the spectral pyramid, each function is further divided into 4 levels which are considered as decks. The decks named as Policy, Strategy, Resources and Operations-Quality Assurance.

Institute exclusive ***policies*** for each face of spectral pyramid need to be framed and must support all functional requirements under each face. The institution ***vision*** and ***philosophy*** has to support to make good ***'policy'*** decisions in all aspects. Appropriate ***strategies*** are essential to implement any policy decision. And this also must reflect on all four faces equally. The institute ***'Mission'*** and ***'Goals'*** may support to take appropriate ***'strategic'*** decisions. ***Resources*** are very important for any organization to get effective implementations of policies & strategies. The adequacy of resources plays a major

Fig. 1. functions of Spectral Pyramid with color code.

role to achieve excellence in all four faces. To maintain adequate resources and its optimum utilization, the institute's timely ***'Objectives'*** and ***'Plans'*** gives a provision in short-run and as well as in long-run. Finally, ***Operations and Quality Assurance*** looks at the bottom level of pyramid which reflects operational activities under four faces based on policies, strategies and resources. The support of human resource is essential to achieve quality operations. The ***'Metrics'*** and ***'Quality assurance'*** are the major dependent factors for effective operations.

Fig. 2. Decks and inside structure of Spectral Pyramid

The mapping of four functions with the deck's combination reflects on the constructed 30 building blocks inside the Pyramid along with colour coding as shown in the above figure.

C. Building Blocks Phase (Process Groups)

No more than three levels of headings should be used. See Table I for formatting details and Subsection **Error! Reference source not found.** above for an example.

The above two levels depict the arrangement of process groups in the form of spectral pyramid. The navigation shows the number of blocks arranged in four levels in a pyramid form gives the number as one, four, nine and sixteen blocks. Each block carries same colours given for four faces. In this phase, the names are given to each block to group the similar processes as shown in table.1

TABLE I
NAVIGATION OF BUILDING BLOCKS BASED ON DECKS AND FACES

Deck	Block Code	Name of the Block
Policy	101	Governance: Academic, Administrative, Financial and Public Relations
Strategy	201	Admissions, Curricula Design & Academics
	202	Teaching Learning Process, Examination & Evaluation
	203	Research, Innovation & Industry Interaction
	204	Planning, Development and Budget
Resources	301	Physical resources & Infrastructure
	302	Human Resources - Students, Academic Performance & Success Rate
	303	Human Resources - Faculty & Staff and Feedback System
	304	BoS, PEOs Mapping with Program Outcomes
	305	External Collaborations, MOUs & Visiting Faculty
	306	IT infrastructure - internet, Wi-Fi, IIS, Web, Computers, Software & Peripherals
	307	Self-Learning Resources Library, Digital Library
	308	Student support Progression & Alumni Interaction
	309	Facilities, Infrastructure & Ambiance Maintenance
Operations & Quality Assurance	401	Academic Calendar & Innovative Practices
	402	Accreditation by: Statutory Bodies, Industry and R&D organizations
	403	Quality Assurance TQM – ISO 9000
	404	Audit: Academic, Administrative, Financial
	405	Student Career Guidance a Structured MTP Roadmap
	406	Academic Delivery Process, Content Development, Management and Innovative Practices
	407	Additional contents, tutorials, Remedial classes & bridge Courses
	408	Academic/domain Laboratories and Lab Protocols to meet Curriculum Requirement as well as PEOs
	409	Research, Consultancy and Patents
	410	Research Projects, Grants, Publications & IPR
	411	Industry institute interface
	412	Incubation labs
	413	Entrepreneurship Development
	414	ECA, CCA & Professional Society Activities and Achievements
	415	Certification & Vocational Courses and Finishing School
	416	Future use

D. Tiles Phase (Processes):

Each block in the pyramid structure has six sides as shown in the fiture3.8. The names of each tile are mapped with functional names of the EPR Spectral Pyramid. And numbered as "F1 Tile, F2 Tile, F3 Tile & F4 Tile". The Top(T) and Bottom(B) Tiles are treated as Top level administration and Metrics respectively.

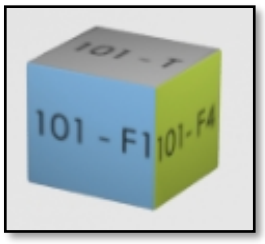

Fig. 3. Building Block with tiles numbers

TABLE 2
TITLES OF THE BUILDING BLOCK

Face of the Block	Title
Top(T)	Administration & Governance Processes
Face-1(F1)	Academic Processes
Face-2(F2)	Research Processes
Face-3(F3)	Innovation and Entrepreneurship
Face-4(F4)	All Round Development – Global Vision & Social Responsibility Activities
Bottom(B)	Metrics

Based on the above table, the number of selected and updated processes have been grouped under the above titles of 29 building blocks and 1 block left for future use to meet the fifth objective. In conclusion, each process is mapped with the above groups of building blocks to reflect four functions of the pyramid.

Efficiency of human resource performance can be accomplished after communicating and implementing the spectral pyramid concept to all stake holders along with innovative practices and technology. ***The Institute Performance Index(IPI)*** depends on the competence & proficiency of the above four management procedures to achieve excellence in four sides around the pyramid. And ***Faculty Performance Index(FPI)*** can also be measured with the consideration of these decks of management procedures and educational functions. This is the reason to consider faculty perceptions on EPR Spectral Pyramid while implementation of this concept.

According to the architecture of EPR Spectral Pyramid, these four decks of management procedures have been applied in each function of management and also to the inside building blocks which are called as process groups. This structure explained in the following section.

IV. RESEARCH DESIGN & HYPOTHESES

The above objective of testing the EPR Spectral Pyramid concept is to identify the critical success factors which is being proved with the specific research design. This design is extracted from the EPR spectral pyramid concept, followed by formulated hypotheses, sample determination, statistical techniques & fuzzy logic approaches. Hence, the focus on the major factors extracted from EPR Spectral Pyramid Model and framed following design for present study:

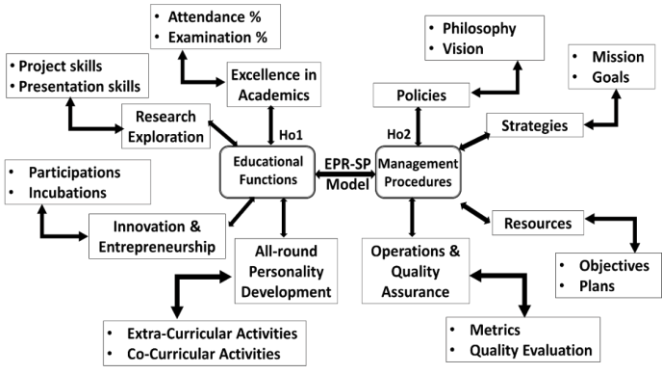

Fig. 4. Framework of research study and finding hypotheses

Based on the above research design, the critical success factors and its metrics have been identified and have examined the metrics from faculty perceptions after adaptation by an institution with the following hypotheses:

H_01: There is no significant association among higher education functions (Academic excellence, Research exploration, Exhilaration of Innovation and All-round Personality Development) to produce quality graduates.

H_01a: There is no significant association between student attendance and exam performance to achieve Academic Excellence of graduates.

H_01b: There is no significant association between student Projects and Presentation skills to get Research exploration.

H_01c: There is no significant association between Student Participations and Incubation ability for exhilaration of Innovation & Entrepreneurship among graduates.

H_01d: There is no significant association between ECA and CCA activities for All-round Personality Development of graduates.

H_02: There is no significant association among Management Procedures (Policies, Strategies, Resources and Quality Operations) for Institute towards excellence.

H_02a: There is no significant association between Institute Philosophy and Vision to make effective Institute Policies.

H_02b: There is no significant association between Institute Mission and Goals to frame timely Institute Strategies.

H_02c: There is no significant association between Institute Objectives and Plans for allocation of adequate Resources.

H_02d: There is no significant association between Metrics and Continuous Evaluation to perform Quality Operations under all functions.

V. EVALUATION AND RESULTS

According to Cochran's formula for sample size, 372 required and sample taken is 392 which out of 11000 faculty in the city colleges. Among them designations and experience is considered to distribute the questionnaire. Out of 372, 43 Professors, 71 Associate Professors and 278 Assistant Professors were identified. The faculty in the Professors and Associate Professors cadre are also working for administration of the institutions as Heads of the Departments, Directors, Deans, Faculty-in-charges for administrative activities.

TABLE 3
SAMPLE COMPOSITION BASED ON EXPERIENCE

Less than 5 Years	6 to 10 Years	10 Years Above	Total
113	188	91	392
28.83%	47.96%	23.21%	100%

Table 3 denotes sample composition by experience. 28.83% of the faculty have less than 5 years' experience, 47.96% of the faculty have 6 to 10 years' experience and 23.21% of the faculty have 10 years and above experience.

The research used primary as well as secondary data. The collection of primary data is through the prescribed questionnaire, whereas the secondary information has been collected through journal publications, conference presentations, textbooks, research reports, paper articles, etc.

To analyse the faculty perception based on questionnaire and collected data, the statistical tools such as Kaiser-Meyer-Olkin(KMO) Sampling Adequacy test, Factor Analysis: Variance extraction method, Principal Component analysis, Mean, Standard Deviation, Correlation analysis, Pearson's Chi-Square test, One-way ANOVA have been implemented with the help of SPSS 20.0 Software.

VI. CONCLUSIONS AND DISCUSSIONS

KMO and Bartlett's test and correlation-regression methods are used to check sample adequacy and justifiability to conduct factor analysis. The KMO value of factor analysis is 0.602 which indicates that sample size is adequate to perform factor analysis for the 36 variables and the Bartlett's test of Sphericity test is to find the presence of correlation among the variables.

Communalities are the proportion of variance described by the common factor. Its value ranges from 0 to 1. The factor analysis has been performed to 36 variables. For all the variables the extracted communalities are above 0.5, hence all the variables are considered for the factor analysis.

According to the test, all the variables have been condensed to seventeen (17) components which explains more than sixty three percent (63%) of the total variance. The selected 17 factors groups based on the rotated component matrix along with the factor loadings extracted from the principal component analysis with varimax rotation are above 0.5.

To test the hypotheses, Mean, Standard Deviation, Pearson's Chi-Square, one-way ANOVA have been performed. The following consolidated table shows the results of hypotheses with statistical analysis:

Null Hypotheses	Mean	SD*	χ^2 (Chi-Square)	Sig.	ANOVA (ρ Value)	MS**	df***
$H_0$1	4.4834	0.8705	34.9443	0.000	0.0063	0.0204	11
$H_0$1a	4.5523	0.8868	10.5282	0.324	-	-	-
$H_0$1b	4.3622	0.8886	62.2887	0.005	0.0057	0.01207	5
$H_0$1c	4.3125	0.9841	44.9954	0.000	0.0339	0.00504	5
$H_0$1d	4.2207	1.0761	5.0476	0.2824	-	-	-
$H_0$2	4.4503	0.8809	51.5958	0.000	0.0174	0.01	11
$H_0$2a	4.2781	0.7286	60.5811	0.000	0.0112	0.0085	11
$H_0$2b	4.4617	0.9701	37.3935	0.000	0.0472	0.0016	5
$H_0$2c	4.4401	0.8644	16.3779	0.000	0.0193	0.0026	5
$H_0$2d	4.4923	0.9222	29.4303	0.000	0.001	0.1992	5
*Standard Deviation, **Means of Squares, ***Degree of Freedom							

From the above table, $H_0$1a and $H_0$1d are not rejected due to the acceptance of no correlation between attendance and academic performance for H01a, similarly, no correlation between ECA and CCA to make all-round personality development for $H_0$1d. So, the input parameters have changed for academic excellence and all-round personality development. Hence, in the place of attendance, self-learning is added to achieve academic excellence and for all-round personality development, ECA/CCA has combined as one input and behavioral attitude is added as second factor.

According to the findings all four-educational functions along with metrics have independent significance and all are equally important to achieve the institution goals through reengineering process with the help of management operations of Policies, Strategies, Resources, and Quality Operations with their critical success factors. Based on the above tests results it is concluded that among 10 hypotheses eight are rejected and remaining two are accepted based on the faculty perceptions

VII. LIMITATIONS OF STUDY

Due to the wide range of expansion in education sector in India, this study is focused on Higher education and especially in the fields of engineering and management. Due to the time and efforts to create EPR structure with education processes and the adaptation process, the focus and study is limited to one campus that contains two higher education institutions of engineering and management located in Hyderabad, Telangana, India.

VIII. FUTURE SCOPE

The concept of process reengineering has vital importance in all business sectors, and its expansion into the education sector has high scope to create standard criteria, structures, targets, etc. for the development of Indian education sector. As the Government of India is focusing on the development of the Indian Universities and Institutions to be placed among top 200 Global institutions, this research area will help to expand focus on EPR to adopt by any of the Technical Institutions that aims for excellence.

This concept gives lot of future scope to study more number of frameworks, and methodologies testing multiple sample institutions. The EPR spectral pyramid gives scope to enhance the process level by layering more building blocks around the pyramid. This study presented 30 building blocks with 4 levels. By adding one more layer around the pyramid the total blocks reach 76 Blocks (30+36) with five(5) levels to fulfil future requirements with more key performance indicators. The spectral pyramid model leads to a software development for academic Institutions for quality evaluation gives more scope to conduct research on computer science area on EPR lines.

The process implementation of Fuzzy Logic evaluation for academic excellence has emerging research area with vital importance in current scenario and can also lead to future research in management field. The future evaluation method may extend to implement the fuzzy systems to assess the academics all dimensions which gives scope to conduct multi-disciplinary research.

Fig. 5. Building Block with tiles numbers

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