ERP Life-cycle Management for Aerospace Smart Factory: A Multi-disciplinary Approach

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ABSTRACT
The research proposes a "conceptual- ERP-framework" for a smart factory during technology diffusion "mega-projects". Application of knowledge discovery and classification algorithms is applied to draw probabilistic inferences based on FP-Growth-algorithm without ignoring the "balanced scorecard (BSC)-model-driven architecture" which is embedded with business intelligence. The prime objective being to illuminate research and scholarly understanding for strategic-alignment of design of vital artifacts of Enterprise resource planning systems (ERP) through collaborative-multidiscipline initiatives amongst the disciplines of "Software-Engineering, Engineering-Management, and Business Science" to overcome the challenges of designing an ERP-system.

Keywords
ERP, e-learning, "BSC" life cycle management, Smart Aerospace Factory.

1. INTRODUCTION
E-Commerce business model reiterates the importance of innovation and values proposition in e-learning for professional training and on job training(OJT). Planning an enterprise-resource-planning (ERP) for an aerospace enterprise's innovation and growth has gained vital importance in the global village. The enterprise-wide software applications for smart factory and smart-campuses have emerged as inevitable for business and industrial competitiveness. Despite it being a multimillion dollar market, ERP still does not come up to the expectations of users of smart-factories and smart-campuses. One reason is the poor scenario planning for 'what if' situations which at the moment is not exhaustive and does not harness all the vital artifacts for ERP-modules. The global village has witnessed a rapid growth in E-learning market form $435M in 1998 to $4213M in 2005 [1]. Similarly SAP, Oracle, Microsoft, SAGE, People-soft and others generate a aggregate revenue amounting to Danish Crowns (DDK) 3000 approx every year worldwide through sales of Enterprise Systems (ES/ERP).[2]. As per researcher "Madapusi" [3], the benchmark study released in 2002, by World Information Technology and Services Alliance, predicted an expenditure on information and communication technology(ICT) in 2001 at about $2.4 trillion, and they expect it to grow at a rapid rate. In 2003 it was estimated that market for ERP systems is quite huge within IT Sector with more than 30,000 companies having implemented ERP systems worldwide and this market is growing due to disruptive technologies. Interestingly, disruptive technologies have enabled the world to be a global enterprise and have opened various avenues for improvement and growth leading to opportunity in R&D for Business, Industry, Engineering, Education, Finance, industrial-psychology and sociology etc. Researcher [3] also argued and conducted case studies to provide a solution to existing enormous ERP alignment-challenges. The researcher reiterated that, "With the globalization of trade and economics, large multinational enterprises are turning to enterprise resource planning (ERP) systems to meet their international information management needs. However, misalignments between the firm's ERP system and its international strategy can often result in unsuccessful ERP implementations and sub-optimal business performance". Today the global-economy is facing a devastating escalation in the history of mankind. The economy escalation project could be considered as a projectized activity. The conservation of resources through project management, technology-management and resource planning can be seen as the only variable and decisive tools for sustainable growth in a global-society. Conversely, the part of the solution could be optimum-learning as a diminutive as well as foremost leap towards "knowledge-based economy". The optimum learning is vitally important during technology diffusion projects where innovative-knowledge is diffused to recipient enterprise or a smart factory. In a smart-factory scenario, computer integrated manufacturing (CIM) is employed for hyper-economical and hyper-efficient operations. In aerospace-industry, CIM-operations require optimum-knowledge-diffusion during on job training (OJT), professional-training, operations-certification and aviation-professional-licensing for engineers and Pilots. During such technology diffusion projects, ERP-software with embedded LMS (learning management system) can be utilized for OJT, professional knowledge diffusion and optimum-learning management.

2. METHODOLOGY AND DESIGN
The limited literature in ERP-technovation was the **"raison-d'être"** to conduct this research. This paper proposes a systems approach (input output model) to deal with ERP-LMS dynamics, for OJT, professional e-learning scenarios for a smart aerospace factory. The contribution of this research is multifold, as compared to previous research. First, it proposes a balanced scorecard (BSC) life cycle management approach based on Diffusion of innovation (DOI)-theory. Then it proposes a socio-technical solution based on TQM philosophies and Artificial intelligence for continuous improvement of ERP employing frequent pattern mining road-map to forecast "what–if" scenarios.

Which is vital to model the ERP's learning-module dynamics. Finally, an aerospace-MRO, case study is accomplished and a real-world application of FPG-algorithm is conducted to predict frequent pattern for ERP–LMS to elucidate its applicability in favor of proposed methodology.

3. SCENARIO PLANNING FOR SMART FACTORY'S ERP

The future scenario planning for realizing the dream of smart factory as forethought by German Professor "Zuehlke" for the research project "PAK" [4] could bring innovative grwoth and econmic sustainability but only through a multidicpline endavour. The resercher [5] has presented scenario Planning Techniques ranging from deterministic-planning, probabilistic-planning to finally scenario planning**,** so as to provide insight for manging futuristic risks in aerospace technology-diffusion-mega-projects. Scnerio planning is more than a heuristic technique to provide qualitative-judgemnt similar to systems-approach. The Scnerio planning is beyond what national strategy and beyond what master planning can even think of. As per researcher[6], scnerio-planning is a "….. hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points". Contextually this research presents a scenrio for fully automated factory with ERP-suites employed at distant apart plants of a smart-factory with offshore trainers during technology diffusion (difusion of technovation-DOT) mega-projects. During such DOT-projects intime OJT and on the spot expert advise is vital during JIT based operations at a aerospace-smart-factory. During DOT frequent instances arise where production-line is halted whenever e.g a multi-axis, state of art CNC-machine, malfunctions; thus requiring offshore expert advise and e-lerning lessons. Teleconferecing and e-leraning labs are thus required at every such loction of an enterprise to handle any work stoppage situation. The unnecassary details about scnerio-planning are skipped for the moment to proceed further to inscribe vital variables of the ERP-artifacts. It is argued that "Business-science discipline, social-informatics discipline and industrial-Engineering discipline augmented by software-engineering-discipline" can render a "balanced and efficient–scorecard", as perceived by researcher Norton Kaplan [7] for optimum human computer interaction. The prime objective of ERP-unified database as proposed by researchers [2, 8, 9] is to economize use of resources (in-puts) [10] during e-operations-management and during "learning-transformation process". This in turn would deliver enhanced outputs augmented by improved quality of services. This research would focus to evolve set of artifacts for e-learning based on BSC lifecycle management. To tackle the issue a case-study of an "aerospace-MRO" was investigated for identifying the artifacts of "e- learning in a smart factory". During the technology mega projects a major complaint by the e-learners specially the "professional engineers, Technologists, research scholars and students" etc, was lack of comprehension. The most vital contributory element was "Technical-trainer's deficiency" to comprehend and realize the learner's preferences for learning innovative information. The other contributory factors were the deficiency to effectively demonstrate new skills during OJT-sessions utilizing a balanced blending of VAK techniques. VAK stands for visual, auditory and kinesthetic which is considered the basic theme for effective and efficient intercommunication skills using a balanced mix of three basic VAK-constituents for e-learning. These factors in turn caused sub-optimal diffusion of knowledge in e-Learning scenario. The simulation-planning is then conducted utilizing artificial intelligence techniques (FP-Growth algorithm) to explore conditional probabilities for uncertain scenarios. The frequent pattern and "what if" analysis in the dimensionality of BSC could become the basis for Xtreme programming and improvement of existing ERP-applications. Which would then indeed lead to customer satisfaction and enhanced ROI. ERP is a customer-driven product, as per researcher [11] "In the context of a customer-driven product or service design process, a timely update of customer needs information may not only serve as a useful indicator to observe how things change over time, but it also provides the company a better ground to formulate strategies to meet the future needs of its customer".

4. SMART FACTORY INNOVATION LIFE CYCLE BASED ON DOI THEORY

As per Moller [2] past researchers have reviewed the ERP concepts available in literature through "an ERP lifecycle model reflecting the adoption process". After analysis of numerous "lifecycle models" it was concluded "that the common denominator is the distinction between pre-implementation and post-implementation stages…….which lack an explicit usage stage". It was also identified that up to 30 per cent of the research in the ERP deals with implementation issues. These researches, however lacked innovation aspects within the life cycle management. Disruptive technologies bring attractive innovation forcing societal-systems to accept and pursue change. The new idea or product gets infused and provides enhanced services until a better replacement is fostered. The researcher [12] inscribed the two fundamental theories for ERP life cycle, Factor-View and process-View. The latter is the neglected-research area and has its basic-roots from DOI-theory. It is hence rational to inscribe a robust and flexible design for ERP so as to accept innovative changes in business-process through WOOM architecture[13] for quicker, faster implementation and customization whenever ERP require adaption in business-processes due to disruptive-technologies. In this research visionary directive of "diffusion of innovation theory" (DOI-Theory) [14] were utilized for " balanced-life-cycle planning" of an e-Learning ERP (eL-ERP), so as to reap the benefits for "optimum knowledge diffusion" in pursuit of hyper-efficient operations management in an aerospace smart factory.

4.1 Social science contribution; harnessing Dimensional Perplexities

The classical concept of DOI, [14] (Technology /Knowledge) has been characterized as "the process by which Knowledge (an innovation) is transfused through communication channels over time among the members of a social system". It was inferred that professional training department at a smart factory or a smart-campus required an integrated system of management for collaborative success, as per the dictates of diffusion of innovation & technovation model [14]. It has been identified that the diffusion of knowledge is directly proportional to the strength of factors like "source, diffusion medium, diffusion social environment and Organizational-timing" in a smart aerospace factory [15, 16]. Higher level of these factors is predicted to achieve optimum knowledge-diffusion . The DOI-thinking was considered paramount for "optimum e-Learning and diffusing critical thinking topologies" into the learners-brain-ware as dictated by blooms taxonomy [17, 18]. Conversely, learning is from cradle to grave, hence DOI could become the most viable and relevant theory since it envelopes the "knowledge diffusion domain" from cradle to grave as per the dictates of system thinking i.e. from start to end (and then reuse). Hence DOI-theory could be utilized to "initiate, plan, execute and close-out as well as reuse knowledge-diffusion projects" [19]. The Fichman-model [20] presented a philosophy commonly known as "non-classical DOI model" which renders comprehensive set of supplementary and critical factors for diffusion of innovation (DOI) in information-technology scenario .

4.1.1 Proposed framework of ERP-E-learning along DOI- lifecycle

The researches [21, 22] proposed E-commerce business aspects, while researchers [15, 23] have evolved factors and risks to organizations during technovation (diffusion of technology). The ERP-performance improvement plan(PIP) has a time-dimension[14] which when mapped over Project management time-dimension can render better comprehension of technovation and change management along a Cartesian-axis (figure-1). This "hybrid time dimension" for ERP-Technovation has various phases which are considered as the basic fundamentals of DOI-processes and are as follows:

Phase I : ERP based e-Learning-Innovation(LMS) exposure and realization in smart-factory specific to technology diffusion projects(technovation) .

Phase II: Willingness and endavour to attain ERP-e-learning-technovation.

Phase III: Decision making to persuade ERP-LMS-Innovation.

Phase IV: The technovation-Implementation phase which in fact is a projectized activity "e-learning -Innovation projectized activity comprising of Initiation-stage, Planning-stage, Execution-stage, .Controlling-stage and Close-out-stage" figure-1. The technovation implementation phase is futher elaborated in figure 3 since it can be blended with balanced scorecard & simulted over project management implementation-phase [15, 23].

Phase V: ERP-e-learning- technovation –confirmation or reuse of knowledge for next ERP iterative cycle.

Based on diffusion-innovation life cycle, artifacts of a ERP model for knowledge based economy is proposed as elucidated at figure-1. The X-axis represents the DOI-phases. An enterprise would realize and initiate performance improvement plan(PIP) as dictated by productivity-theory[10]. Decision for ERP-enhancement and continuous improvement based on TQM –philosophy would trigger set of concurrent activities among various actors for requirement planning, scope planning, scenario-planning and establishing all plausible scenarios. Past researchers have proposed use of AHP [24, 25] and QFD [26-28] and other tools for translating voice of customer to software-programmers. This is followed by software-development or modification and finally software testing cycle which may involve extensive iterations till dream is realized for aerospace-smart factory.

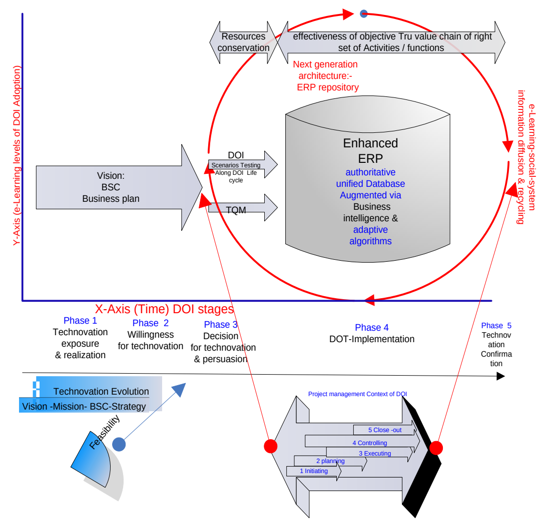

Figure 1: ERP generic framework for smart factory mega projects.

A major deficiency with existing ERP-suites is lack of adaptability and flexibility to align with dynamically changing-business-scenarios. To address such deficiencies researcher [13], introduced a "design and implementation of a new generation of enterprise planning system, Web-ERP, using Web-based Object-Oriented Model (WOOM). ERP is considered as a strategic tool in academia-as well as smart factory. It has been also identified by researcher [29] that various organization have formulated and evolved unique software algorithms for ERP so as to adapt to their business-functions and for application in different disciplines. In the same context universities and industry can develop their own set of algorithms to meet their business needs. Hence it is stressed that generic-ERP-framework at figure-1, needs a total alignment [3] with embedded-adaptability within architecture of ERP-unified database as well as flexibility with dynamics of E-commerce as per WOOM model so as to realize the dream of sustainable global-economy.

5. ERP LIFE CYCLE; A LOCKHEED MARTIN-MRO, CASE STUDY

Having identified the vitality of artifacts of innovation life cycle, now the BSC perspective of business model and its dimensions would be first explored so as to identify the critical requirements to design an "ERP software application" for industrial smart factory.

A Lockheed Martin (LHM)-C130-aircraft-MRO-facility was considered as a case study to articulate applicability of the proposed "ERP-e-learning-framework" during technology diffusion of Enterprise-system (ES)-implementation project. The MRO was involved in technology-diffusion project for which it was acquiring, IBM(Maximo) asset management-Enterprise System (ES). MRO had consultants /e-learning instructors offshore at Turkey and Singapore. These technology consultants and instructors were to support aero-engines and airframe structural DOT-mega projects. The challenge faced by the enterprise was to ensure smooth technology diffusion and at the same time inscribe system-thinking for e-synchronization and for managing all modules considered as islands of automation within ERP and legacy system. These modules were legacy system to support aerospace MRO-operations, Supply chain management, PDM and precision measuring equipment labs (PMEL). MRO had plans to deploy and integrate IBM-Maximo, with legacy-system for optimization of work flow and project management. The OJT and e-learning was the next issue to get e-synchronization with IBM-Maximo. The e-learning scenario was considered vital so as to ensure "effective-learning" as a first diminutive leap towards knowledge-based economy, a scenario-which could be understood in light of past research work [9] , ***"e-Work: the challenge of the next generation ERP systems".***

In this research, to address the issues of enterprise; Engineering-management techniques (systems approach along DOI-life cycle and TQM-continuous improvement philosophy) were employed coupled with artificial-intelligence to address the optimization of e-Learning. The "Aerospace MRO industry environment" was comprised of "perplexed production technologies" and was under strict surveillance of doctrine advocated by Civil aviation authority (CAA) , Joint aviation authority (JAR) national and international standards. The decision to implement ERP-LMS in a big-bang approach was thus discarded since Enterprise Systems were at varying levels of maturity and implementation and production processes required exhaustive business process reengineering. Contextually, a balanced-scorecard technique was introduced (a tool barrowed from business science discipline to address the social-informatics-challenges). The balanced-scorecard (BSC) has four dimensions namely learning/Innovation, business processes focus, customer focus and financial dimension. The balanced scorecard is considered as the most viable and competent tool for earning business excellence through effective learning [10] for value proposition and revenue generation [7, 24, 30]. As per researcher [10] "the motivation is basic to all human behaviors and thus an effort for productivity improvement…" whereby all aspects of education effect productivity. Thus action-plans are to be instituted for "willingness" to learn so as to trigger "Ability" (first scorecard) which would then lead to business excellence and quality improvement (2nd Scorecard). The business process excellence would then earn customer satisfaction (3rd Scorecard). Which then would realize the dream of smart aerospace factory in terms of economic stability, ROI and productivity (4th Scorecard). The concept is elucidated in figure 3. The irrelevant details are for now skipped so as to focus on basic and important artifacts of ERP design framework along innovation life cycle:

Phase I : ERP based operations mangmenmt and e-Learning-Innovation(LMS) exposure and realization specific to technology diffusion projects was identifed by the aerospace MRO.

Phase II: Determination and willingness for ERP-e-syncronized resource mangment and LMS for Innovation was persued. The IBM expert team visitied the MRO-facility and integration tests were conducted for IBM-Maximo (Asset Management System) with MS.General-Dynamics leagacy Enterprise System. The BOM and desighn-configuration(PLM) data was migrated and a perfoarmance improvement feasibilty demonstration was conducted for top mangment.

Phase III: Decision making to persuade ERP-LMS-Innovation was concurred and budgetary reports were solicited however non availability of employing AHP or QFD studies for ensuring budgetary overruns was skipped due to top visioanry rating for IBM-maximo at Gatrner magic quardarent [31, 32].

Phase IV: The MRO hired consultant for project-mangement for smart campus or smart factory DOI-Implementation phase "operations mangment and e-learning-Innovation activity, comprising of Initiation-stage, Planning-stage, Execution-stage, .Controlling-stage and Close-out-stage". Two most risky scenerios were identifed for the MRO after focus group research, one being the JIT based Unified modeling (UML) for complex strucutured aerospace MRO operations. In second scnerio UML was portraid whereby capacity requirment planning for MRP was enahanced multifold by 3X to simulate uncertaininties by enahcing maximum plausible-capicity to 12 aircraft per Dock. While preparing UML the visionary dictates were solitated from past reserch work of researchers like Zhen et-al, [33-35]. The stability of IBM-maximo for simulations of uncertain scenerios couldnot be accessed due to confidentality issues.

Phase V: The consultant did not realized the importance of reuse and did not consider ERP- opearions and e-learning-Innovation–confirmation or reuse of knowledge for next ERP iterative cycle. IBM software supportability for future enhancments were not explored exhaustively to point out "what-if" scnerios. The proabable rationale being the visioanry rating for IBM-maximo at Gatrner magic quardarent, which is even higher than SAP and other rivals[31, 32]. The production planning and control (PP&C) department MRP design consideration are elobrated in figure 2, where as the BSC life cycle for ERP-design consideration is elucidted in figure 3.

Based on MRO-case-study, a planned transformation of balanced-scorecard was initiated as indoctrinated by researcher **[10]** for ERP-e-learning life cycle management along DOI-phases. While data mining techniques can predict precise regression-models for R&D financial expenses in years to come, along this abstract balanced scorecard (BSC) dimension (figure-3), yet the prime focus is only to highlight the vitality of e-learning/ learning organization life cycle along DOI stages. The idea abstracted here would go a long way for fetching balanced perspective for not only financial-aspects but for customer, internal-business-perspectives and learning and innovation in a smart campus and smart-factory. The "*e-learning life cycle"* mapping can be carefully correlated to the pattern identified through inferential statistics or FP-growth algorithm to predict a balanced financial perspective for ERP–PIP and ERP-R&D-projects.

5.1 Vital Artifacts of ERP design & Frequent pattern classification and mining

Past researchers have identified numerous dimensions and vital variables for ERP-e-learning. The data-mining of major research databases like, EBSCO , Web of science(TS), etc would deliver gigs of data which would render no definite beginning and no definite way to explore or identify principle dimensions for ERP-design for a smart factory or smart campus.

The literature survey coupled with text mining and Analytical-techniques identified that past researchers have predicted numerous vital dimensions [1] and six vital variables [36]for an innovative e-learning, the summarized principle dimensions are :-

(a) Quality management of ERP-LMS.
(b) "Optimum Knowledge diffusion" and commercialization of innovative ideas through innovative-learning-techniques and pedagogy.

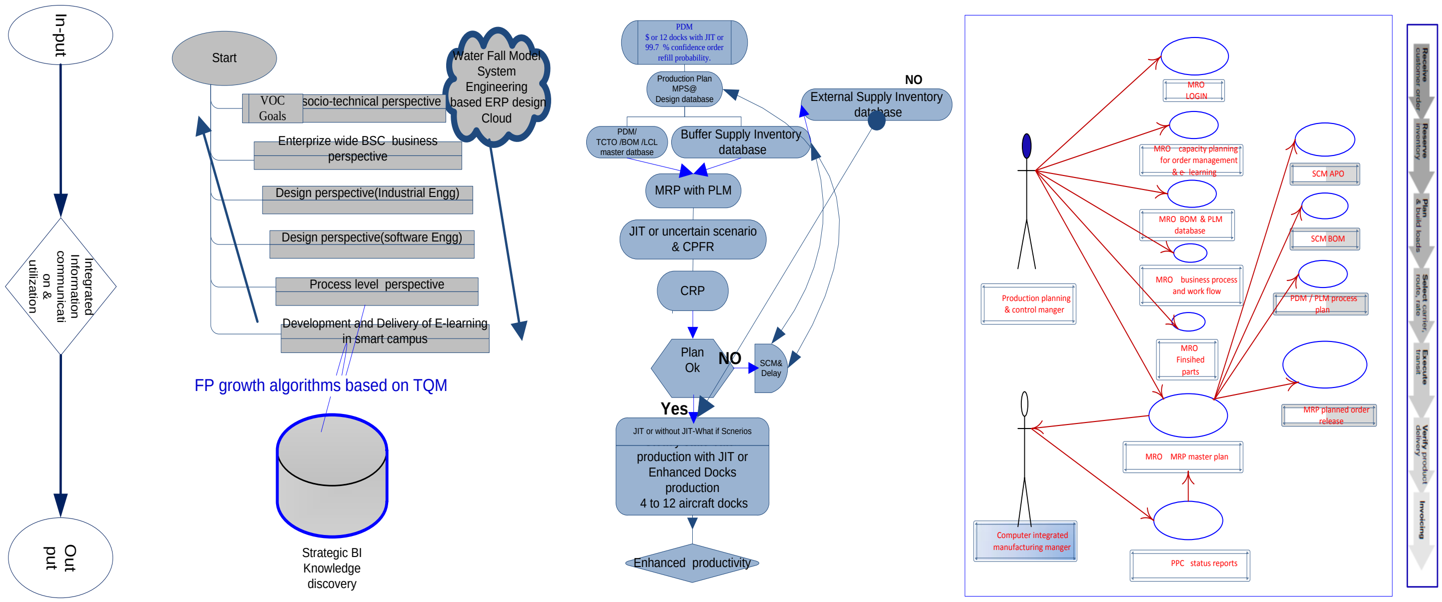

Figure 2: Conceptual systems-approach for PIP of ERP unified modeling use-case diagram (adopted from [33-35])

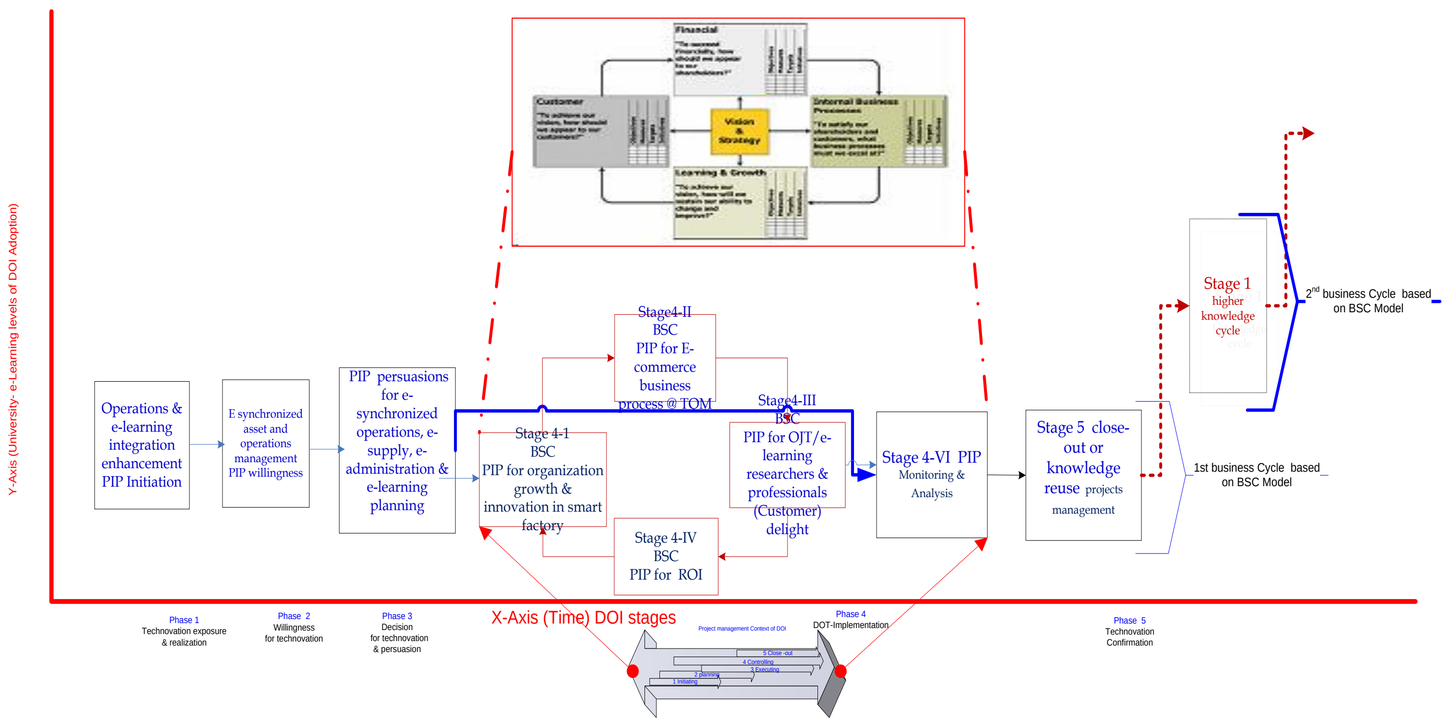

Fig. 3: Conceptual Balanced scorecard mapping over ERP, life cycle as per E-Commerce Model (adopted from [23, 24])

(c) Competitive teams for collaborative teamwork to implement e-Learning programs utilizing IT/ICT & disruptive technologies with an aim to exploit economic value of innovative ideas.

(d) Knowledge exploitation through commercial inventions so as to render optimal benefit to society (European TQM award model stresses about 9% (approx) significance to such aspects).

Contextual to same a data set of e-learning critical-factors was formulated through literature review. These factors were considered as transactions for mapping along BSC life-cycle as shown in table 1. Conversely knowledge discovery algorithms were critically analysed and selected to identify and predict frequent patterns as well as synthesis for scenario planning in a smart factory in pursuit of excellence.

Legend : Gallager [1] , Susanne [36] , Edward [37] , Asif [23] , Zuehlke Detlef [4], Elisabeth [38],

Table 1 : FP growth data sets; frequent datasets for exhaustive scenario-planning of ERP-design artifacts (1st scorecard)

Transaction Researcher	Financial Aspect (I1)	Customer Aspect (I2)	Business processes (I3)	Learning & Growth (I4)
T1. Gallager	**Y**	**Y**	**Y**	**Y**
T2. Susanne		**Y**	**Y**	**Y**
T3. Edward		**Y**	**Y**	**Y**
T4. Asif et al.		**Y**	**Y**	**Y**
T5. Zuehlke	**Y**	**Y**	**Y**	**Y**
T6. Elisabeth		**Y**	**Y**	**Y**

5.1.1 Application of FP-Growth for Vital frequent pattern identification.

The FP-growth algorithm is one of the fastest means to fetch and mine frequent transactions "item set" [39]. It manages and eliminates "multiple .scans of transaction database". It thus divides and conquers general conception of Apriori for the massive candidate's workload and support counting. The FP-Growth advantage is in its objective to divide-and-conquer. FP-Growth decomposes both the mining task and DB according to the frequent patterns. It then proceeds to focused search of smaller databases along with other factors. A case for vital artifacts was explored for Vital-ERP /e-Learning variables. The Data-set was considered that contained a four by four matrix (four researcher's transactions for vital variables and its mapping along balanced scorecard dimensions.) The minimum support considered was 30%. The FP growth algorithm[21] was deployed for mining and to predict all possible scenarios (frequent pattern) for vital artifacts of ERP-design considerations.

Algorithm: FP-growth*: Version 4.18 by researcher* [39] *was utilized for mining frequent patterns*
Input: A Vital E-leaning & ERP dataset (table-1) developed during literature survey, and a minimum support threshold ξ *(30%)*.
Output: The complete set of frequent pattern set (table 2).
Method: Call FP-growth *Version 4.18 by researcher* [39]

5.1.2 Results Assumptions & Limitations

While more refined iterations and selection would have fetched interesting patterns, however for ease of understanding only four transactions were considered. Since the focus was to indicate the viability and potential of FP-growth algorithm to explore frequent pattern-set for ERP vital artifacts necessary for design consideration and exhaustive scenario-planning. The resultant plausible scenarios of frequent item set for ERP are shown in table 2.

5.1.3 Vital Artifacts of ERP Landscape

The E-commerce business vision of enterprise systems iterates value chain for knowledge management i.e. a fundamental conceptualization of K-Commerce for sustainable growth and globalized economy. The concept of smart factory and smart campuses reiterate ERP for information integration for competitive advantage in a global-environment. Based on MRO-case study a landscape for artifacts of ERP for e-learning was evolved. The smart-factory ERP artifacts for balanced and sustainable growth would thus require following modules:

Table 2 : FP growth data sets output ; frequent datasets for exhaustive scenario-planning of ERP (1st scorecard); Researcher Transaction selected (T1,T2,T3 & T4)

Researcher item-IDs vital variables	BSC Variables set	Support-count
I4=a	Learning & Growth	4
I3=b	Business processes	4
I2=c	Customer Aspects	4
I1=d	Financial Aspects	1

FPG: Frequent Patterns of BSC
Conditional-probability-Plausible-scenarios for ERP vital artifacts With 30% support count
abcd bcd (100.0)
abcd (100.0)
bcd (100.0)
(Algorithm Time to predict =0.08 Seconds **)**

(a) K-Commerce Module, for Data-warehousing, mining Knowledge extraction, Data simulations, planning , execution , management and commercialization of technovation coupled with Business Intelligence (BI) Module for researchers and management.

(b) BSC business-Model driven scenario simulation and planning adaption algorithm (expert-system) to predict future issues based on FP-growth or other data mining techniques.

(c) e-Learning management system (LMS) module with pattern recognition features to address to deficiencies in training and OJT.

(d) HRM /CRM -Human /Customer Relationship Management (CRM) Module.

(e) Financial Module.

(f) MRP/SCM -Operations Management module

(g) Project Management module.

5.1.4 Analysis

As per researcher [41], "The Enterprise Resource Planning (ERP) system is an enterprise-wide integrated software package designed to uphold the highest quality standards of business process. However, for the time being, when the business condition has been changed, the system may not guarantee that the process embedded in ERP is still best. Moreover, since the ERP system is very complex, maintaining the system by trial and error is very costly". In light of above remarks it is evident that ERP design should at-least explore all plausible scenarios for ERP-architecture based on vision of aligning; ERP Systems with International Strategies[3] , adaptable-ERP for synchronized e-works [9] and WOOM strategy[13]. Contextually, an innovative, concurrent design effort is vital for success of ERP coupled with synchronized industry and academia collaboration. This research conclusively highlighted the significance and importance of multidiscipline-initiatives for ERP-design along balanced scorecard, DOI life cycle.

6. CONCLUSION

This research devised an ERP learning and Knowledge-commerce conceptual framework through a multi disciplinary approach. The performance enhancement was achieved via extraction of balanced set of vital variables through business analytics, business-intelligence (BI), and data-mining techniques. The framework presented a smart factory and campus ERP for knowledge-commerce and knowledge-technovation without ignoring the strategic-reflections, of engineering management's Systems-approach, Business discipline's BSC coupled with DOI-life cycle management. This research rendered a competitive–ERP design framework with blended techniques from various academic-disciplines so as to cater for limitation of any one technique but will ensure optimum effectiveness of all the techniques for optimum knowledge diffusion and diffusion of innovation in a smart-aerospace-factory. The novelty of life cycle management could lead to pavilions for revival of world economy for sustainable growth and development. The ability to work will sustain the inertia for willingness to work so as to render better performances, enhanced quality, optimum customer satisfaction and enhanced revenue generation through economization of resources. The refined and balanced perspective for ERP-design artifacts for a smart factory would always require continuous improvement as per dictates of TQM along the life cycle. The information integration, use, reuse and K-commerce incentives require harnessing the ERP design along life cycle. It is for this reason that ERP-R&D focus and budgets must be realigned as per the vision of balanced-scorecard so as to earn such strategic objectives along the life cycle of the enterprise.

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