International Journal of Software Engineering and Its Application
Vol.11, No.11 (2017), pp.17-30
http://dx.doi.org/10.14257/ijseia.2017.11.11.02

# CMM-based Quality Management Model for Teaching and Learning Process

Anagha Vaidya[1*], Shailaja Shiwaikar[2], Vyankat Munde[3] and Prafulla Bafana[4]

[1]*Symbiosis International University, India*
[2]*Savitribai Phule Pune University, India*
[3]*Savitribai Phule Pune University, India*
[4]*Symbiosis International University, India*
[1]*anagha.vaidya@sicsr.ac.in,*[2] *scshiwaikar@gmail.com,* [3] *Mvv.parli@gmail.com,*
[4]*prafulla.bafna@sicsr.ac.in*

***Abstract***

*Organizations imparting higher education are complex systems with several stakeholders and key process areas. The teaching and learning process in higher education institutes is unplanned and un-managed (ad-hoc), lacks transparency, resulting in poor quality of students and demotivated faculty. The situation prevailing in professional Education setup in developing countries is almost similar to that prevailing a decade ago in software industry which led to the emergence of Capability Maturity Model (CMM) and its adoption by the software Industry to pursue its quality goals.*

*This paper presents a vision of a CMM-based quality Management Model and an Analytical framework incorporating key practices to evaluate and improve the quality of imparted education.*

***Keywords****: Learning Analytics, Capability Maturity Model, Education Data Mining, Enterprise Resource Planning*

## 1. Introduction

Higher education institutes are complex systems with a large number of stakeholders. Though the whole system revolves around the student, there are other important entities such as faculty, industry, governing bodies, financial institutions, suppliers/vendors *etc.*, with varying requirements. The key process areas in any Educational institute are teaching and learning, administration, research, industry interface, community service, National/International collaboration, student welfare *etc.* Since administrative processes are on similar lines as in other business organizations, Enterprise resource planning (ERP) solutions have been extensively used for streamlining these processes. However, the same is not applicable to other key process areas including Teaching and Learning Process.

The problems that are affecting the quality of higher education institutes, in developing countries such as India, are demand-supply gap, teacher-student ratio, lack of transparency and lack of check on quality of imparted education. The teaching and evaluation process in colleges is ad hoc leading to graduates passing out lacking confidence in their abilities. This leads to the problem in industry for getting the right professionals as per their requirements. To address the issue of quality in higher education, researchers in educational field have been working on teaching methods and standards to address teaching quality.

The above problems indicate that the situation prevailing in professional education setup is almost similar to that prevailing a decade ago in software industry. The high demand for software systems had resulted in several software vendors using adhoc

Received (July 1, 2017), Review Result (October 25, 2017), Accepted (November 10, 2017)

ISSN: 1738-9984 IJSEIA

procedures which resulted into poor quality products (Lutteroth,2007). The department of defense in the US, which was the major customer for software, set up the software engineering institute (SEI) which developed the capability maturity model (CMM) which can be used to provide suitable visibility into the capability of a supplier for providing the software service .

The capability maturity model (CMM) prevalent in software industry with its maturity levels and key practices, is found to be the most appropriate model for assuring and assessing the quality of key processes in education sector. (Manjula,2012)

A quality model along with proper supporting tools to incorporate key practices in the teaching and learning process, can address all the issues affecting the quality of imparted education.

This paper presents the quality model in education, an outline of the key initiatives and the analytical framework. The paper is organized as follows: section 2 presents background and related work. The section 3 outlines the different problems affecting the quality in the higher education. The proposed quality model in higher education is described in section 4, the detail architecture framework of the model is illustrated in Section 5. The description of capability maturity levels of proposed model are analyzed in section 6 and conclusion and future work are covered in section 7.

## 2. Background

Each stakeholder of an educational institute has different perspectives, accordingly requires varied services (Lepouras 2010). In literature, the different educational key processes are managed using software solutions which are integrated into an ERP solution (http://pi-learning.espe-aquitaine, http://eshiksa.com, https://www.schooltonic.com). These Education-ERP systems are built around different educational activities like admission system, lab management, class management *etc.* These systems manage physical resources but overlook the most important "teaching and learning" key process area. For addressing the issues related to teaching and learning, it requires the data about learner, their learning pattern, learning activation logs, problem-solving approach, learning interest and behavior. The immediate feedback on teaching process is one of the best practices in teaching-learning activity. This feedback data guides the teacher in the lecture preparation and planning of teaching activity (Kloos 2015). Therefore, the education ERP systems should be strengthened by using learner-centered initiatives.

### 2.1. Technology Support in Learning Process

Apart from traditional classroom teaching, the new technology like mobile learning (Aljohani, 2012), Learning Management System (LMS), open education resource's MOOCs, Information and Computer Technology (ICT) *etc.* are used in education for preparing the students across the globe. These new technological initiatives required systematic planning of the teaching process. This planning required huge amount of data which may be collected through heterogeneous platforms and need to be organized by using a common schema, and reusable portable components (Manske 2014). The massive data is also collected through these processes. Sometime the traditional data mining tools prove to be ineffective (Shum, 2016), requiring new machine learning algorithms or, big-data mining (Yu Taeho 2014) are implementations.

### 2.2. Learning Analytics (LA) and Educational Data Mining (EDM)

Learning analytics is defined as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens 2011, Chatti 2012). It relates to teaching and learning practices and uses a sophisticated analytic tool to improve learning. The analytical tools predict the student success and retention (Smith 2012) and

 

provide the feedback on learning status of the learner, which helps the teacher teach more effectively (Kloos 2015, Dyckhoff 2012, Vozniuk 2014). It also supports "personalized learning" which would enable students to have more effective learning experiences and learn at his own pace (Dix 2015). It also helps the course designers control the content and pace of the course. Therefore, Siemens refers to LA as the "efficient learning hypothesis". (Siemens, 2011) as it allows suggesting of new learning opportunities or different courses of action to students. LA also acts on predictions, and then feed those results back into the process in order to improve the predictions over time (Dix 2015; Van Barneveld 2012).

Education Data Mining has been defined as "an emerging discipline concerned with developing methods to better understand students and the settings in which they learn" (IEDMS 2009). It takes education data and applied data mining techniques such as prediction, relationship mining *etc.* The data is taken from different processes of education system *i.e.* from interactive learning environments, different learning activities, education management system, evaluation process *etc.* The data is analyzed for understanding how students learn, discovering the patterns and trends in their learning process. (Lias 2011, Dyckhoff 2012). EDM supports continual and real-time assessment of student progress in which amount of formative feedback provides opportunity for teacher to understand student's learning pattern (Berland 2014).

### 2.3. Educational challenges and CMM approach

In developing countries the implementation of LA and EDM (Dix 2015), in practice is rigid, due to large number of students in a Class, shortage of trained and qualified faculty. The limitation of traditional test assessment is well-known but those tests remain standard for the ease of administration (Baker 2014), which has significant impact on higher education quality. The teaching and learning process in the higher education are required to be more systematic with research, operation and community outreach activities (Wals 2014). The quality in higher education is achieved by teachers, rather than infrastructure and other resources that represent the organization as a whole. In the existing system, the teacher evaluation is performed only by the student feedback, which happens at the end of the semester and it is quite subjective.

Most researchers have thus argued that the capability maturity model (CMM) prevalent in software industry with its maturity levels and key practices, is found to be the most appropriate model for assuring and assessing the quality of key processes in education sector. CMM ranks organization into one of the five maturity levels and identifies key practices essential to attain and retain a level of maturity as given in Table 1.

**Table 1. Capability Maturity Levels and the Key Practices**

<table>
<tr><th>CMM maturity Levels</th><th colspan="2">Key Practices</th></tr>
<tr><td>Initial</td><td>Processes are adhoc, unpredictable, uncontrolled.</td><td rowspan="2">Establish goals and objectives<br>Planning processes<br>Providing resources<br>Assigning responsibilities<br>Training people</td></tr>
<tr><td>Repeatable</td><td>Some processes are characterized and organized reactively</td></tr>
</table>

| | | |
|---|---|---|
| Defined | Processes are proactively well-defined, well-designed and well-documented. | Inspection and Peer-Review<br>Managing configurations<br>Measuring performance<br>Monitoring performance<br>Controlling processes<br>Improving processes |
| Managed | All key processes are further measured, monitored and controlled | |
| Optimized | Continuous improvement with incorporation of Innovative practices | |

Based on similar concepts, several models are proposed and implemented in education (Chen 2011, Duarte 2011, Lutteroth 2007, Manjula 2012). Chen (Chen 2011), proposed T-CMM model for implementation of teaching learning process. Manjula 2012 proposed four models wherein CMM-IV (η4) focused on teaching learning process.

This paper proposes a CMM-based model along with a set of initiatives to bring in key practices into the teaching and learning process.

## 3. Quality Impediments in Higher Education

The Quality of education greatly suffers due to several obstacles as presented below:

- **Demand Supply gap in Education**: - There is heavy demand of higher educated graduates (professionals) in developing country such as India (Manjula 2012) hence, there is mushrooming of large number of educational institutes, where the lack of resources lead to poor quality of imparted education. Though, there is increase in number of graduates, they are not industry ready because there is no proper monitoring and controlling of teaching and student evaluation process.
- **Teacher-student ratio**: - Although teacher-student ratio is regulated by government norms, it is not practically followed in many colleges. The result is, it is difficult for a teacher to follow continuous evaluation or activity based evaluation of a student. Teacher is not able identify and cater to individual student's needs and take remedial actions.
- **Student progression**:-In current scenario the student progression is performed at the end of a semester. It is performed based only on their end semester results and it is very late to know the student's deficiencies. (Lepouras 2014)
- **Demand of Qualified Faculty**-The increase in demand for teaching faculty is met by pushing new graduates into teaching profession without any prior training or support. Though, this full-time faculty is ready to invest time and energy but lack of experience and guidance.
- **Visiting Faculty** – Highly experienced professionals are entrusted to groom the students but they have time constraints and different priorities. The evaluation process many times gets sidelined and there is no control on the courses conducted by visiting faculty.
- **Transparency between Parents, Industry**: - In the teaching and learning process, the different activities were conducted in the college. The impact of these

 

activities on student personality is not see-through to the main stake holders that is Industry and parents.

- **Team Activity with communication gap** – Grooming an undergraduate into a skilled professional is a team activity and there should be perfect communication between team members to avoid gaps and redundancies. Most of the time each course is delivered in isolation and many times prerequisites are just assumed. The courses are depend on each other; however, teaching of these courses may be carried out in parallel or one after other. In this case, the teacher should be aware of what is delivered in other class and also know the understanding level of concept/skill of the students so that he/she can plan his topic as per these prerequisites.
- **Bridge the Gap between syllabus designer and actual delivery**: - The syllabus designing is carried out by experts at university level however, there is no feedback loop on the problems faced by the delivery team. Many times, courses allotted equal credits vary in content. The actual content delivered may be different depending on the delivering faculty and there is no uniformity.
- **Lack of Quality check on teaching and learning process** - The teaching quality is achieved by not only having subject knowledge, good content delivery but also how the delivered contents are grasped by the student. Generally teaching quality is measured by student's feedback. This evaluation is judgmental; it is the student's subjective feeling about the teacher. This is not on the quality of his teaching method (Chen 2011).
- **Lack of analytics on implementation of best practices in college**: - In existing system there are several so called best practices implemented in ad-hoc manner; however, there is no analytics performed on their implementations hence effectiveness of these practices, is not measured.

The above issues are interlinked and need to be addressed with a holistic approach. The proposed model should be built over the existing ERP solutions by adding new initiatives that will help in defining and managing teaching and learning process

## 4. Proposed Model

CMM believes that processes which are well defined and managed, can lead to better products. The quality goals can be thus achieved by amalgamating the key practices in the teaching and learning process. This requires some new initiatives in the form of 'Teaching by Design', 'Continuous Evaluation', 'Planed Interactions', 'Quality Audit', 'Learning Analytics', 'Knowledge and Pattern Repository' with appropriate key practices and technology support. Technology plays a crucial role in supporting the organizations in moving up the maturity ladder. These new initiatives can be implemented as services as shown in fig 2 and are detailed below.

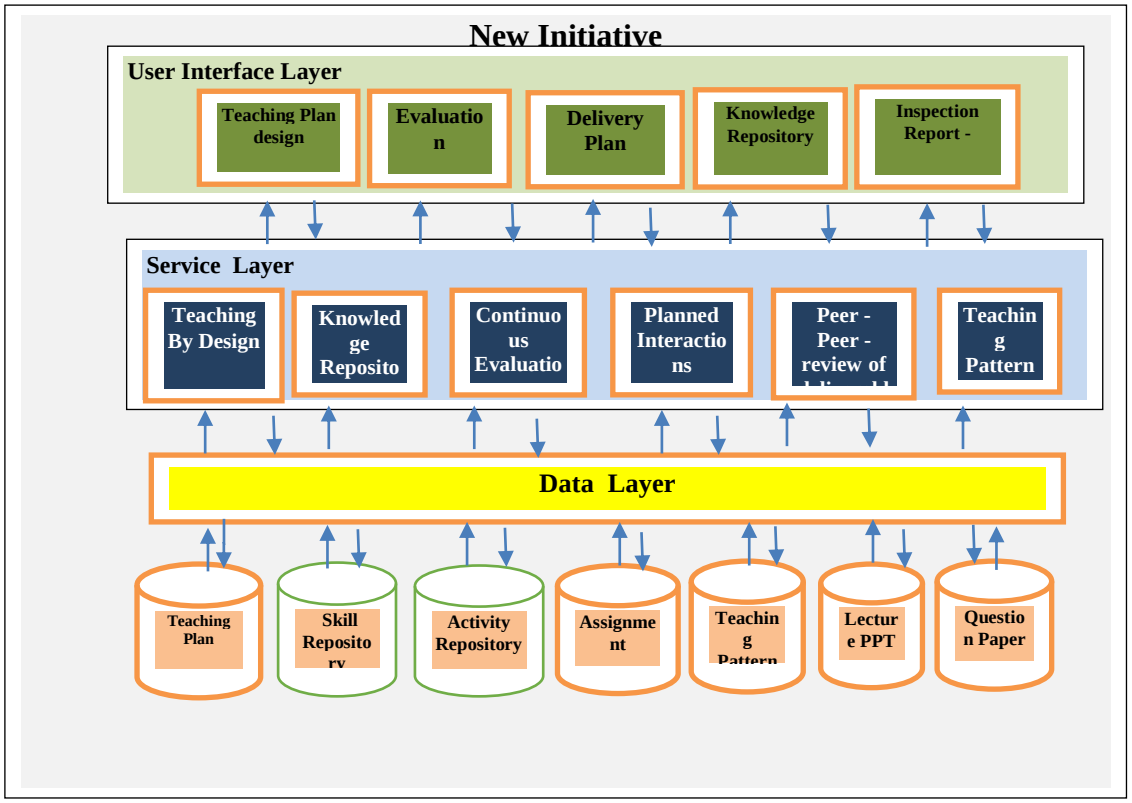


**Figure 1. New Initiative**

- **Teaching by design**

Teaching should not be an ad-hoc process but a well-defined, well-designed and well-documented process. The goals and objectives of any course should be defined first before delivering the contents. A course is not delivered in isolation hence there should be clarity about the pre-requisites, outcomes, other dependent courses, and related parallel courses of it. The delivery of the course may include different activities like interaction sessions, pre-reading, activities, assignments, evaluation process which should be planned properly. Preparing the teaching plan and teaching activities, continuously updating of this prepared plan, requires proper technological support which can be facilitated through adaptation of cloud and mobile technologies.

- **Continuous Evaluation**

The traditional teaching process can be improved by continuously monitoring the outcomes by using the process of continuous evaluation. The evaluation process requires both the question paper generation and answer paper correction. The paper generation can be increasingly automated by incrementally creating a question repository. The answer paper correction can be simplified with the use of OMR technology.

- **Planned Interactions**: -

The teacher has to play multiple roles such as counselor, mentor, guide, demonstrator, instructor, evaluator *etc.* Each role has different responsibilities attached with it. Although, the teacher is same but depending on the role the interactions are different. These interactions should not be subjective but should be meaningful, objective and focused. Tools supporting such role-based planned interactions can help teacher sail through different roles with ease.

- **Learning Analytics :-**

Learning Analytics process is made up of six distinct steps or components: Measurement, Collection, Storage, Analysis, Action, and Communication (Chatti 2012,

Koedinger 2015; Baker 2014). The basic metrics required for actionable analytics can be defined and collected through the computerization of planning, delivery and continuous evaluation process (Rubel 2017). The data can be stored on cloud. The analytics dashboard and reports can be used by teachers and the management to assess and improve teaching and learning process.

- **Quality Audit:-**

In general, the 'teaching audit' is performed at the end of the semester but it assesses only number of lectures conducted and percentage of syllabus covered. The process does not measure the quality of teaching and learning process. The student feedback is another way of collecting data about the quality of teaching which is again a semester-end activity. For improving teaching quality the inspection and peer reviews of the deliverables such as teaching plan, assignment, *etc.*, can be introduced, as a continuous activity.

- **Maintain knowledge repository**: -

The young teacher has difficulty in delivering because of absence of experience, deficiency of knowledge, and lack of teaching skills. He requires guidance not only in the form of resources but also training in techniques. By maintaining knowledge repository of successfully delivered lectures and also the technical guidance, a new recruit can be provided the requisite support. In such a knowledge bank, knowledge is deposited by the experts and it is withdrawn by the new recruits for delivering the content. These knowledge elements can be further improved and redeposited.

- **Pattern Repository** :-

For understanding certain concepts specific examples are found to be effective. The repository can be used to store such examples and counter examples. The repository can also store teaching patterns such as 'teaching by example', 'teaching by analogy' *etc.* or learning patterns such as 'Torrnado of learning' ( Iba T,2009) and ' the first steep' *etc.* By providing an efficient search engine on this repository, the knowledge seekers can be provided the necessary support to deliver effectively.

Each initiative involves certain key practices and associated measurements required to support learning analytics. Table 2 presents each initiative along with key practices and measurements. The various measurement parameters are qualitative and quantitative such as topic, skill, duration, time required for completion of topic, level (hard/easy/medium) *etc.*

**Table 2. New Initiatives, Key Practices, Measurement**

| Sr No | New initiatives | Key Practices | Measurement |
|---|---|---|---|
| 1 | Teaching By Design | Establishing Goal and Objectives | Teaching Plan |
| | | | Assignment plan |
| | | Planning process | Activity plan |
| | | | Evaluation Plan |
| 2 | Continuous Evaluation | Monitor Performance | Question Paper |
| | | | Teaching, Student feedback |
| | | | Student Activity Logs |
| 3 | Planed Interaction | Assigning Roles and Responsibility | Interaction Reports |
| 4 | Quality Audit | Controlling Process | Teaching Plan v/s Delivery |
| | | Inspection Process | Activity plan v/s Actual conduced activity |

| | | | |
|---|---|---|---|
| | | Peer-review | Assignment designing Skills - |
| | | Assign the roles and responsibilities | Question paper review |
| 5 | Knowledge Repository | Training People Improving process | Resource deposits |
| | | | Utilization of knowledge bank |
| 6 | Learning Analytics | Monitoring Performance Measurements and data collection | Student feedback |
| | | | Teacher feedback |
| | | | Analytics Dashboard |
| 7 | Teaching Pattern Repository | Improving process | Pattern deposits Pattern utilization' |

## 5. Architecture Framework

The new initiatives are to be integrated into the existing ERP solutions that are managing administrative student data. The emerging architectural framework is presented in Figure 2.

- **User Interface**:-

The major stakeholders of the system are student, teacher, manager or policy maker and the parents (Baker 2014). The interaction of the stakeholder with the system depends on the role played and decides the design of user interface (UI). However, for user friendliness of the UI for all the stakeholders should include appropriate combination of textual and graphical representations.

The administrative data is collected through the existing ERP system and academic data from the new initiatives. The analytics dashboard provides requisite information and reports to all the stakeholders

Apart from this application specific services the layer is also responsible for providing the services of Searching, Discovery, Analysis and Mining, Recommendation, Visualization, Authorization and Authentication, Registry, Administration / Monitoring *etc.*

 

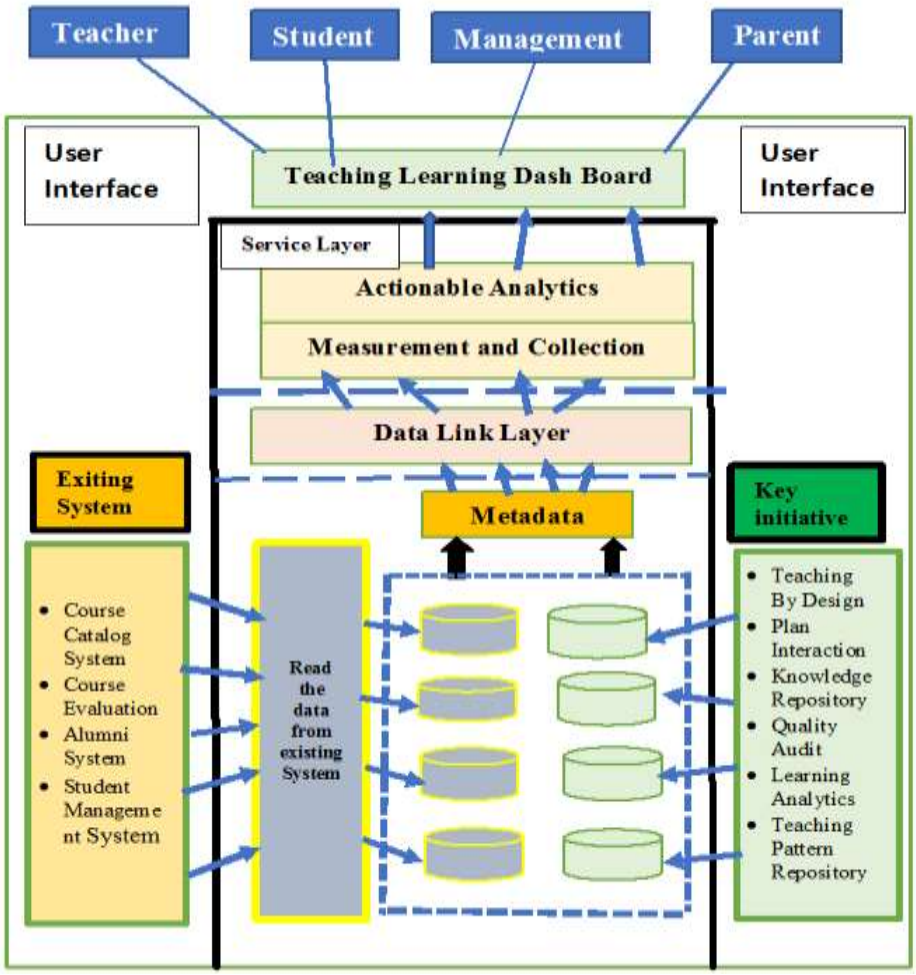


**Figure 3. Architectural Framework**

- **Service Layer: -**

The layer is responsible for performing the following task:-

1. Measurement – extracting appropriate parameters from the data collected into the system through ERP systems as well as the new initiatives. The deliverable of the different initiatives and the measurement parameters in the form of qualified or quantified attributes is explained in Figure 4. Acronyms used in the Figure 4 are detailed in Table 3.

2. Actionable Analytics –Appropriate analytics or mining algorithms can be applied on collected data to extract patterns on which decisions can be based.

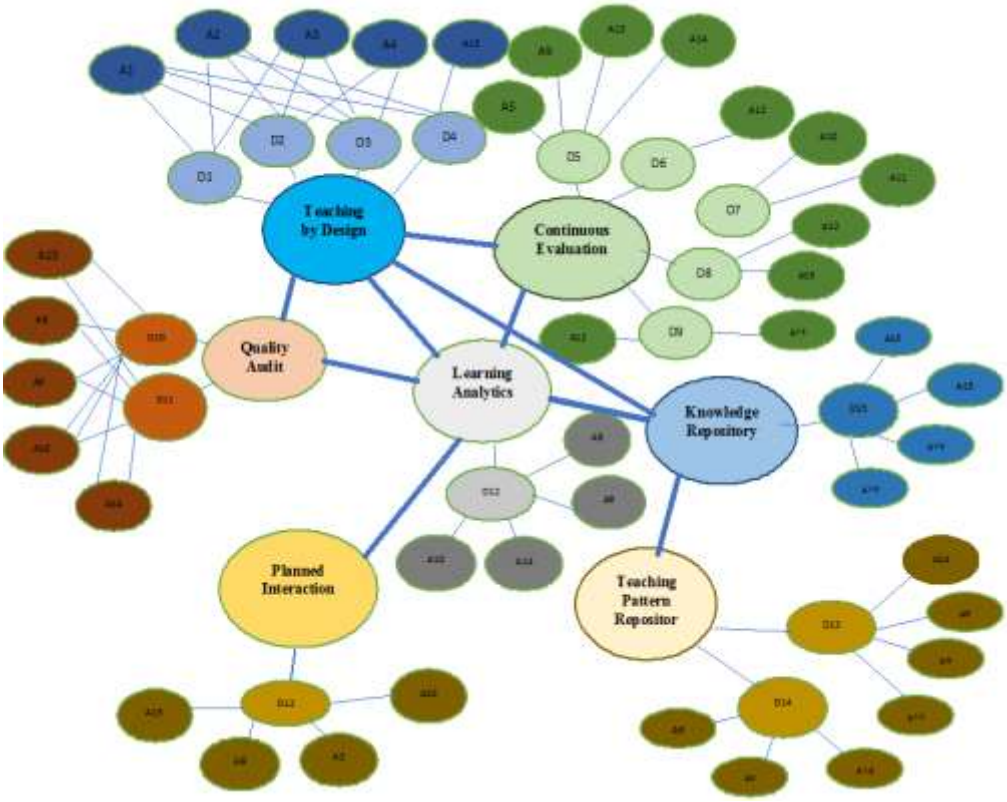


**Figure 4. Measurement Parameters**

**Table 3. Acronyms for Measurement Parameters**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Deliverables from New initiatives** | | | | | | | | | |
| D1 | Teaching Plan | D2 | Assignment Plan | D3 | Activity Plan | D4 | Evaluation Plan | D5 | Question Paper |
| D6 | Evaluation Report | D7 | Student Interaction plans | D8 | Student Feedback | D9 | Teacher Feedback | d10 | Inspection report |
| D11 | Review Report | D12 | Actionable Reports | D13 | Learning Patterns | D14 | Teaching patterns | D15 | Resources/ knowledge elements |
| **Quantified or Qualified Attributes** | | | | | | | | | |
| A1 | Skill | A2 | Level | A3 | Duration | A4 | Units | A5 | Type of questions |
| A6 | Number of questions | A7 | Reference count | A8 | Author | A9 | date | A10 | frequency |
| A11 | Approach towards problem | A12 | Score /Marks/grades | A13 | Type | A14 | content | | |

- **Data Link Layer**: -

This layer is responsible for communication with the database and service layer. This layer is responsible for common storage schema, metadata repository, maintenance of ACID properties, data dictionary, reduced I/O cost, query processing and optimization, Indexing and file management.

 

- **Database: -**

The data is collected through the existing system and new initiative. The data is collected through Student Management System, Course Catalog System, Course Evaluation System, and Alumni systems, social and professional networks. Academic data is collected through the new initiatives like teaching plan, continuous evaluation, learning analytics *etc.*

## 6. Capability Maturity levels

Every Educational Organization will by default be at initial level and should work towards attaining higher levels of maturity. The maturity levels of an organization can be identified based on the initiatives implemented and the associations between maturity level and the initiatives is depicted in figure 4.

- **Level 1: - Initial**: - Similar to SE-CMM, here all processes are adhoc and chaotic. There are no standards or defined formats and it is poorly controlled. The teaching and learning process starts without any planning. The success totally depends upon the competency of the persons and their previous experience which they might repeat. There is no proper feedback or continuous evaluation mechanism hence the decisions are based on the end semester result which is too late.
- **Level -2 Repeatable**: - The two initiatives – "Teaching by Design" and "Continuous Evaluation" may be partially and selectively implemented. Some of the practices automated in these initiatives may be in place in some departments. This could be not an organization level but individual or departmental level initiative. These good practices are productive and may be repeatedly used over years for good results.
- **Level 3 Defined**: - Three initiatives "Teaching by Design", "Continuous Evaluation" and "Planed Interactions" are implemented in the organization with full technical support. All deliverables from these initiatives are properly defined, documented and stored collectively.
- **Level 4 Managed**: - All key processes are further measured, monitored and controlled. The data about the execution of teaching learning process is collected and stored for further analysis. The appropriate policy and procedures need to be defined for quality reviews. The different data mining techniques are used and actionable reports are generated from the collected data. This is achieved through the new initiatives "Learning Analytics" and "Quality Audit".
- **Level 5 Optimized**:-Processes are continually improved based on a quantitative understanding of the common causes. The performance of the teaching and learning process can improve through incremental and innovative technological and pedagogical changes. The new initiative "Pattern Repository" and "Knowledge Management" stores the existing practices and takes the technological support for optimizing the best practices.

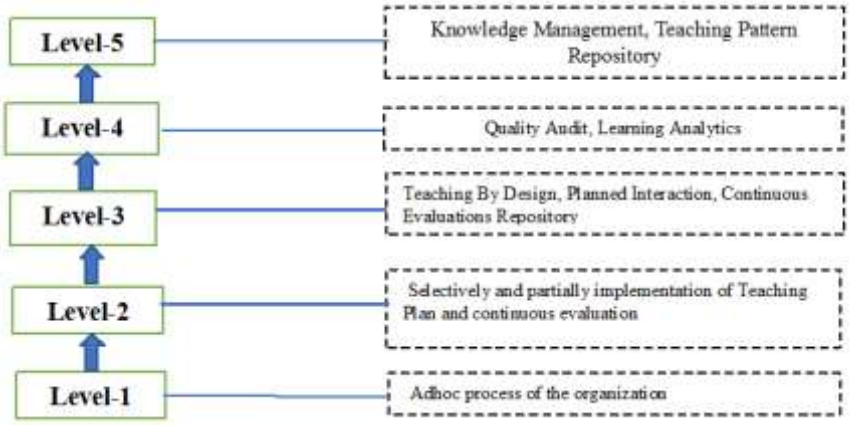


**Figure 5. CMM Model**

## 7. Conclusion and Future Work

Advances in computer technology has brought major paradigm shift in education by introducing techniques like mobile learning, MOOCs *etc*.. Although these new techniques are used in education to supplement the traditional learning processes, but the basic key practices in education need to be systematically organized. This can only be achieved by properly defining education process providing statistical analysis on the Learner Behavior and continuous feedback and improvement of the teaching process. This proposed quality management model with properly designed and developed tools to support key initiatives will help overcome many of the challenges faced by higher education institutes.

## References

[1] N. R. Aljohani and H. C. Davis, "Significance of learning analytics in enhancing the mobile and pervasive learning environments", In Next Generation Mobile Applications, Services and Technologies (NGMAST), 2012 6th International Conference on, IEEE, **(2012)**, pp. 70-74.
[2] R. S. Baker and P. S. Inventado, "Educational data mining and learning analytics", In Learning analytics, pp. 61-75. Springer New York, **(2014)**.
[3] M. Berland, R. S. Baker and P. Blikstein, "Educational data mining and learning analytics: Applications to constructionist research", Technology, Knowledge and Learning, vol. 19, no. 1-2, **(2014)**, pp. 205-220.
[4] J. P. Campbell and D.G. Oblinger, "Academic analytics", EDUCAUSE review, vol. 42, no. 4, **(2007)**, pp. 40-57.
[5] M. A. Chatti, A. L. Dyckhoff, U. Schroeder and H. Thüs, "A reference model for learning analytics", International Journal of Technology Enhanced Learning, vol. 4, no. 5-6, **(2012)**, pp. 318-331.
[6] C. Y. Chen, C. Y. Kuo and P. C. Chen, "The teaching capability maturity model for teachers in higher education: a preliminary study", In 2011 International Conference on Frontiers in Education: Computer Science and Computer Engineering, **(2011)**.
[7] A. J. Dix and J. Leavesley, "Learning Analytics for the Academic: An Action Perspective", J. UCS, vol. 21, no. 1, **(2015)**, pp. 48-65.
[8] N. Duarte and P. V. Martins, "Towards a maturity model for higher education institutions", In Proceedings of the 23rd International Conference on Advanced Information Systems Engineering Doctoral Consortium (CAISE 2011), vol. 731, **(2011)**.
[9] A. L. Dyckhoff, D. Zielke, M. Bültmann, M. A. Chatti and U. Schroeder, "Design and implementation of a learning analytics toolkit for teachers", Educational Technology & Society, vol. 15, no. 3, **(2012)**, pp. 58-76.
[10] T. Iba, M. Toko, M. Naruse and N. Yotsumoto, "Learning patterns: A pattern language for active learners", In Conference on Pattern Languages of Programs (PLoP), **(2009)**.
[11] "IEDMS. International Educational Data Mining Society", Retrieved April 22, 2013, from. http://www.educationaldatamining.org/, **(2009)**.
[12] C. D. Kloos, A. Pardo, K. R. Koedinger, S. D'Mello, E. A. McLaughlin, Z.A. Pardos and C. P. Rosé. "Data mining and education", Wiley Interdisciplinary Reviews: Cognitive Science, vol. 6, no. 4, **(2015)**, pp. 333-353.

 

[13] G. Lepouras, A. Katifori, C. Vassilakis, A. Antoniou and N. Platis, "Towards a learning analytics platform for supporting the educational process", In Information, Intelligence, Systems and Applications, IISA 2014, The 5th International Conference on, IEEE, **(2014)**, pp. 246-251.
[14] T. E. Lias and T. Elias, "Learning analytics: The definitions, the processes and the potential", **(2011)**.
[15] C. Lutteroth, A. Luxton-Reilly, G. Dobbie and J. Hamer, "A maturity model for computing education", In Proceedings of the ninth Australasian conference on Computing Education-Volume 66 (pp. 107-114). Australian Computer Society, Inc. **(2007)**.
[16] Manjula and J. Vaideeswaran, "A New CMM-Quality Education (CMM-QE) Framework using SEI-CMM Approach and Calibrating for its Process Quality and Maturity using Structural Equation Modeling–PLS Approach", International Journal of Software Engineering and Its Applications, vol. 6, no. 4, **(2012)**, pp. 117-130.
[17] S. Manske, T. Hecking, L. Bollen, T. Göhnert, A. Ramos and H. Ulrich Hoppe, "A flexible framework for the authoring of reusable and portable learning analytics gadgets", In Advanced learning technologies (icalt), 2014 ieee 14th international conference on, IEEE, **(2014)**, pp. 254-258.
[18] A. Rubel and K. ML Jones, "Data Analytics in Higher Education: Key Concerns and Open Questions", **(2016)**.40.
[19] S. B. Shum and R. D. Crick, "Learning Analytics for 21st Century Competencies", Journal of Learning Analytics, vol. 3, no. 2, **(2016)**, pp. 6-21.
[20] G. Siemens and P. Long, "Penetrating the fog: Analytics in learning and education", EDUCAUSE review, vol. 46, no. 5, **(2011)**, p. 30.
[21] V. C. Smith, A. Lange and D. R. Huston, "Predictive modeling to forecast student outcomes and drive effective interventions in online community college courses", Journal of Asynchronous Learning Networks, vol. 16, no. 3, **(2012)**, pp. 51-61.
[22] V. Barneveld, K. E. Angela, Arnold, and J. P. Campbell, "Analytics in higher education: Establishing a common language", EDUCAUSE learning initiative, vol. 1, no. 1, **(2012)**, pp. l-ll.
[23] A. Vozniuk, S. Govaerts, L. Bollen, S. Manske, T. Hecking and D. Gillet, "AngeLA: Putting the teacher in control of student privacy in the online classroom", In Information Technology Based Higher Education and Training (ITHET), IEEE, 2014, **(2014)**, pp. 1-4.
[24] A.E.J. Wals, "Sustainability in higher education in the context of the UN DESD: a review of learning and institutionalization processes", Journal of Cleaner Production, vol. 62, **(2014)**, pp. 8-15.
[25] T. Yu, and I.-H. Jo, "Educational technology approach toward learning analytics: Relationship between student online behavior and learning performance in higher education", In Proceedings of the Fourth International Conference on Learning Analytics and Knowledge,ACM, **(2014)**, pp. 269-270.

## Authors

**Anagha Vaidya**, she has a Ph. D in Computer Management under Savitribai Phule Pune University. She is working as a faculty of Computer Science under Symbiosis International University. She has 15+ years of experience in teaching. Her research interest is in Learning Analytics and Educational Data mining.

**Shailaja Shirwaikar**, she has a Ph. D. in Mathematics of Mumbai University, India and worked as Associate Professor at Department of Computer Science, Nowrosjee Wadia College affiliated to Savitribai Phule Pune University, Pune for last 27 years. Her research interests include Soft Computing, Big Data Analytics and Software Engineering.

**Vyankat Munde**, he is a research scholar at Savitribai Phule Pune University.

**Prafulla Bafna**, she is an Assistant Professor in the Symbiosis Institute of Computer Studies and Research, Symbiosis International University (SIU), Pune, Maharashtra, India. She has a MPhil (Computer Sc), Yashwantrao Chavan Maharashtra Open University (YCMOU) and M. Sc. (Computer Science), Savitribai Phule Pune University. Her research interests include Data mining and Human computer Interaction(HCI).

 