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Capability Maturity Model for Higher Education

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ABSTRACT

We propose a maturity model for Management education which is inspired by the Capability Maturity Model (CMM) used in software engineering. Similar to CMM, the Higher Education Maturity Model (HEMM) can be used to rate educational organizations according to their capability to deliver high quality education on a five level scale. Furthermore, HEMM can be used in order to improve an institution's capability by implementing the best practices and organizational changes it describes.

This study explores a CMM model suitable for education sector to improve the people practices and education level processes. For this purpose we have selected Capability Maturity Model (CMM) as our base model and People Capability Maturity Model (PCMM) and Capability Maturity Model Integrated (CMMI) as helping models for quality improvement in higher education sector.

Key words: Education, CMM, Quality, Maturity, HEMM

INTRODUCTION

The need for a proper framework of quality has gained paramount importance due to the growing demand for quality in higher education. The need for determining the existing maturity of education, the government's growing emphasis on spreading quality education among masses and the increasing competition among educational institutions are some important factors that have set quality demand in motion. In order to sustain educational standards, efforts are being made in the international educational sector to employ different quality frameworks, for example, ISO9000 and Total Quality Management (TQM). These quality frameworks, however, are basically designed for industrial sectors and have to be carefully customized to meet the needs of the educational sector. Hence there is a need of a process model that improves the quality of educational level processes in a cost effective way.

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The process maturity framework was designed for application to practices that contribute directly to the business performance of an organization, that is, to the organization's capability for providing high-quality products and services. Since the capability of an organization's processes is critical to its performance, the practices for managing and developing them are excellent candidates for improvement using the maturity framework. Thus, the CMM has been designed to increase the capability of the processes.

Knowledge is the raw material of education. Although educational tools can help record and manage knowledge, they do not create and apply it. Perhaps no industry in history has been as knowledge intense as education, an industry whose only product is proceduralized knowledge in the form of students. Not surprisingly, the level of talent in any educational institute is often the strongest predictor of its results and personnel shortfalls are one of the most severe risks. The presence of an extraordinary individual in any institute can have dramatic impact. The pace of technical change and the depth of knowledge required to implement complex systems require extensive investment in process learning. Increasing the capability of processes is necessary to:

- meet growing demand for education while faced with a talent shortage,
- Master the accelerating pace of change in technology, and business applications, and
- increase the reliability of education systems, especially in life-critical and business-

critical applications.

The process maturity framework constituted a unique approach to organizational development that could be applied in areas other than software development. Organizations other than software also suffered serious shortcomings in workforce management. These workforce-related problems included inadequate training, inaccurate performance feedback, crowding, lack of career opportunities, and noncompetitive compensation. Many software organizations discovered that improvements to their development practices required significant changes in the way they managed people. Same is true for the educational organizations too. Most improvement programs were focused on process or technology, not people. In response to requests from many software organizations, the SEI initiated a project to produce a model for improving workforce practices guided by the principles underlying the CMM, with some tailoring

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which can be aplicable to education sector also.

Analogy between software development and education

Teaching and software development have a lot in common. The similarities between software development and education are as follows:

- Both are complex activities, both undergo a development life cycle, and we would like both to be of high quality, despite finding this difficult to measure.
- In both domains, a main ingredient of success is good structure and the use of best practices, i.e. a process that helps us to structure and do things right.
- The process by which software is developed is not directly visible in the quality of the end product. Teachers, however, can influence the end product of their work only indirectly.
- Software development projects correspond to courses as they are taught, in contrast to a course as an abstract concept. Somehow a course has to be defined: what is taught, when is it taught, how is it taught and what is the measure of success (e.g. exam marks)? All these questions are very familiar to lecturers, and it helps to have most of them answered before the course is taught. Now, the same what, when and how—but of course with a different context—have to be answered for a software development project, and constitutes what is commonly understood as software development process. Software development is not the only analogy one can draw; a course is similar to other processes as well. However, in the context of higher education it seems particularly appropriate to refer to processes of software engineering. If processes are so important for the quality of the product—and many disciplines agree in this matter— then we should spend time and effort on improving them.
- We acknowledge that many factors affecting educational success are of a human nature: good teachers make a difference, and teaching and learning are greatly influenced by the personal interactions between teachers and students. Nevertheless, the benefits and support provided by a high-quality educational process should not be underestimated.

Maturity Models

Maturity models in areas involving process and high-performance delivery are proving to be useful because they allow individuals and organizations to self- assess the maturity of various aspects of their processes against benchmarks. As faculty seek to improve their courses, it is important to know the attitudes, satisfactions, and outcomes of the students; however, these alone do not

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always provide the guidance necessary to identify which practices or processes should be planned or improved next. A maturity model may help faculty assess their courses in relationship to best practices and prioritize course improvement actions.

Watts Humphrey and his colleagues at IBM first developed the concept of the maturity model in the early 1980s. They noticed that the quality of software (conceptual, product, delivery) developed was positively correlated with the quality of the processes used to develop it. They and others found that process improvement had to come in a series of steps, rather than simultaneously. The U.S. Department of Defense became involved in the mid-1980s by funding the development of the Software Engineering Institute (SEI) at Carnegie Mellon University. Humphrey (1989) took his ideas to SEI and there the maturity model framework was formulated (SEI, 2001).

Maturity models are typically constructed with five levels. Each maturity level is a plateau in which one or more processes have been transformed from a lower level to achieve a new level of capability. Consequently, we can say that as an online course is transformed by providing learning opportunities not available at a lower level, it has then reached a new level of maturity. Each maturity level provides a new foundation of practices on which subsequent levels are built.

Higher Education Maturity Model

The framework of the maturity model for higher education (HEMM) has been formulated from the capability maturity model for software. Through as faculty move towards higher and professional education, they tend to incorporate the technology slowly. As they teach professional courses, they try to add media and components in order to raise the quality of the course. In my experience it becomes confusing as to which process or practice should be attempted next. Using the HEMM introduces faculty to best practices in steps, provides an integrated system that causes the course to mature in best practices as the faculty course designer increases alignment among best practices, learning principles, technologies, student and faculty objectives, performances, and changing needs.

Since the HEMM is an evolutionary framework, it assists faculty in selecting improvement actions in course design based on their own available technology, best practice knowledge and capability, and that of the students. The benefit of a maturity model such as this is in narrowing the scope of improvement activities for faculty to those most vital and accessible,

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and at the same time providing the next foundational layer of maturity. By concentrating on a focused set of practices and working toward implementing and measuring them in the course design, the faculty can continuously improve their course design and make substantial gains in student outcomes.

The philosophy implicit in the HEMM can be summarized through several principles:

- A mature course design based on best practices, partnered with principles of good instruction, is likely to be positively correlated to student outcomes.
- A mature course design shifts the focus from passive to active learning on the part of the student.
- Student performance can be continuously measured and improved at multiple levels through multiple means.
- Improving student outcomes by individualization of instruction is possible through principles of online best practices and good instruction and technology.
- The improvement of student outcomes can be pursued through an integrated set of proven best practices and processes.
- The instructor is responsible for providing as many best practices as currently known and feasible, while the students are responsible for taking advantage of them.
- Since technologies evolve rapidly and best practices change as technologies evolve, the highest level of maturity will continue to ascend in quality and ultimately potential student performance.
- Institutional standards and incentives can facilitate achieving new levels of maturity in course design.

Structure of the Maturity Levels

The HEMM consists of five levels, moving from the initial level (Level 1) to Level 5,

the integration of best practices (see Table 1). Each level has five process areas (PA), each of which identifies a series of practices that, when utilized as a group and built on the prior level, will potentially create an environment supporting increased student performance.

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Table 1

Higher Education Capability Maturity Model

	Key Process Areas				
	Course and Components	Staffing	Teaching pedagogy	Socialization and Interactivity	Assessment
Level 5 Integrating Best Practices	•Develops learning objects •Process Change Management •Technology Change Management •Processes integrated and linked	•Total Faculty Involvement Continuous • Faculty Development	•Resources supporting learning preferences •Interactive learning aids •Self-regulated learning •Learning objects matched to student needs & interests •Learning preference awareness •Choices on path, practice •Provides integration of processes	•Community of learners •Collaborative problem solving & critical thinking •Social presence •Alignment of learning preferences to practices	•Multiple assessments for student performance and course improvement •Feedback for effective self-learning •Multiple options for expressing knowledge •Learning preference • Documented Feedback •Defect prevention
Level 4 Planning	•Learning objects to meet course goals •Well-structured content • Institutional Process Performance • Educational Quality Management	• Faculty capability Management • Empowered • Faculty Mentoring	•Students filter, integrate, and disseminate knowledge • Learner-instructor partnership	•Student-generated discussion •Student facilitation of task & maintenance of groups •Collaborative tools used •Sensitive to student needs	•Versatility of methods •Peer review of work •Student-instructor readiness for online work also • Quantitative Process Management
Level 3 Stimulating	•System approach of institution •Integrated programme management •Documented process management	•Faculty training •Intellectual property management	•Faculty and students comfortable with use of new technology	•Faculty-controlled discussions •Sensitive to student participation •Frequent contact	•Test pools •Papers from student to instructor
Level 2 Innovating	•Educational requirement management •Degree programme planning	•Faculty hiring programme	•Educational quality assurance	•Solution programme management •student support process	• Degree programme monitoring and control
Level 1 Initial	•Syllabus •Course information	• No planning for faculty hiring	• Lecture method without feedback	• No interaction	•None

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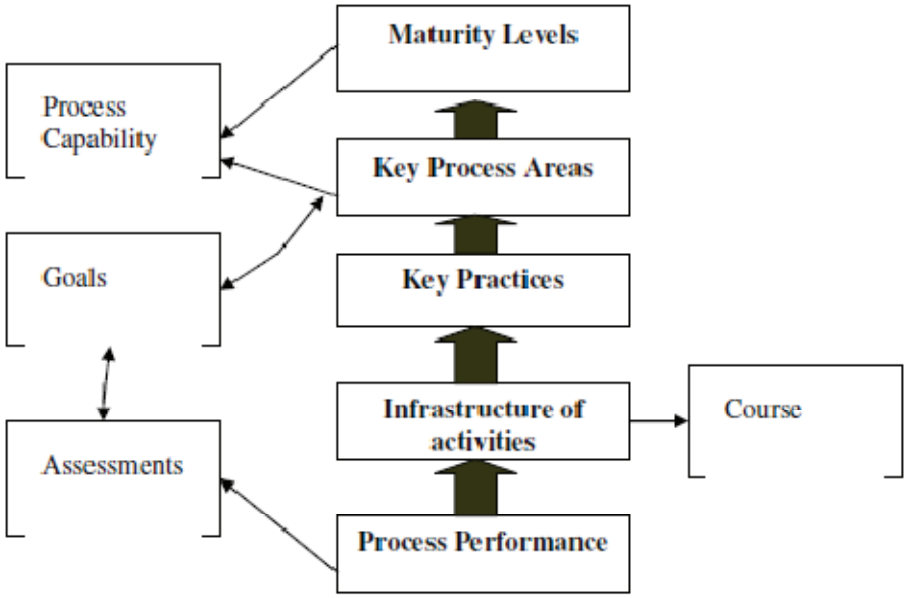
Figure 1. Relationship of HECMM components



Key Process Areas

The key process areas in the model were identified by a literature review of best practices in higher educations, which were then categorized into five process areas. Each PA for each maturity level identifies a cluster of related practices and activities that, when used collectively, may achieve an important goal for enhancing performance capability (see Figure 1). The decomposition of each maturity level ranges from general guidelines to specific practices found to be successful in the literature. A process is defined as a domain with a set of activities, practices, and transformations that faculty may use to improve the quality of the course. Assuming the designer uses the principles of good teaching as a foundation, the course matures in quality as additional best practices are integrated and consistently implemented; consequently, Level 5 is the compilation of best practices currently identified in the literature.

Process Capability

The range of expected results that can be achieved by following a specific set of practices within a process can be defined as a process capability. The process capability provides the means of predicting the most likely outcome to be expected based on the literature. For example, if the literature shows that the way the screen is designed has more effect on learning than the content, then we can predict that well-designed screens will produce the potential

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for higher performance by students than poorly-designed screens.

Process Performance

A process performance represents the actual results achieved by following a best practices process. Process performance focuses on the results achieved, while process capability focuses on results expected. In the example above, the actual measurement of the learning outcome as a result of the well-designed screen is the process performance.

Process Maturity

Process maturity is the extent to which the practices of a specific process are designed, managed, measured, controlled, and deemed to be effective. Maturity implies a potential for growth in capability and indicates both the integration of best practices in the online course and the consistency with which they are applied throughout the course design. It may be possible for a designer to include the practices of Level 4 course and components process and yet not use the practices of some of the other Level 4 processes. However, since Level 5 integrates all five processes, it would not be possible to attain Level 5 course maturity without the use of all processes. Each maturity level has a general goal that relates to the purpose of that level (see Figure 2). The set of key practices for each PA reside at a single maturity level according to the level of skill, knowledge, and technology required utilizing them. All PA practices at each maturity level must be implemented in order for the course to be mature at that level.

There may be other Process Areas with additional activities that are not included because they were not as widely published in the literature, but may become part of the best practices at the fifth level as time goes on.

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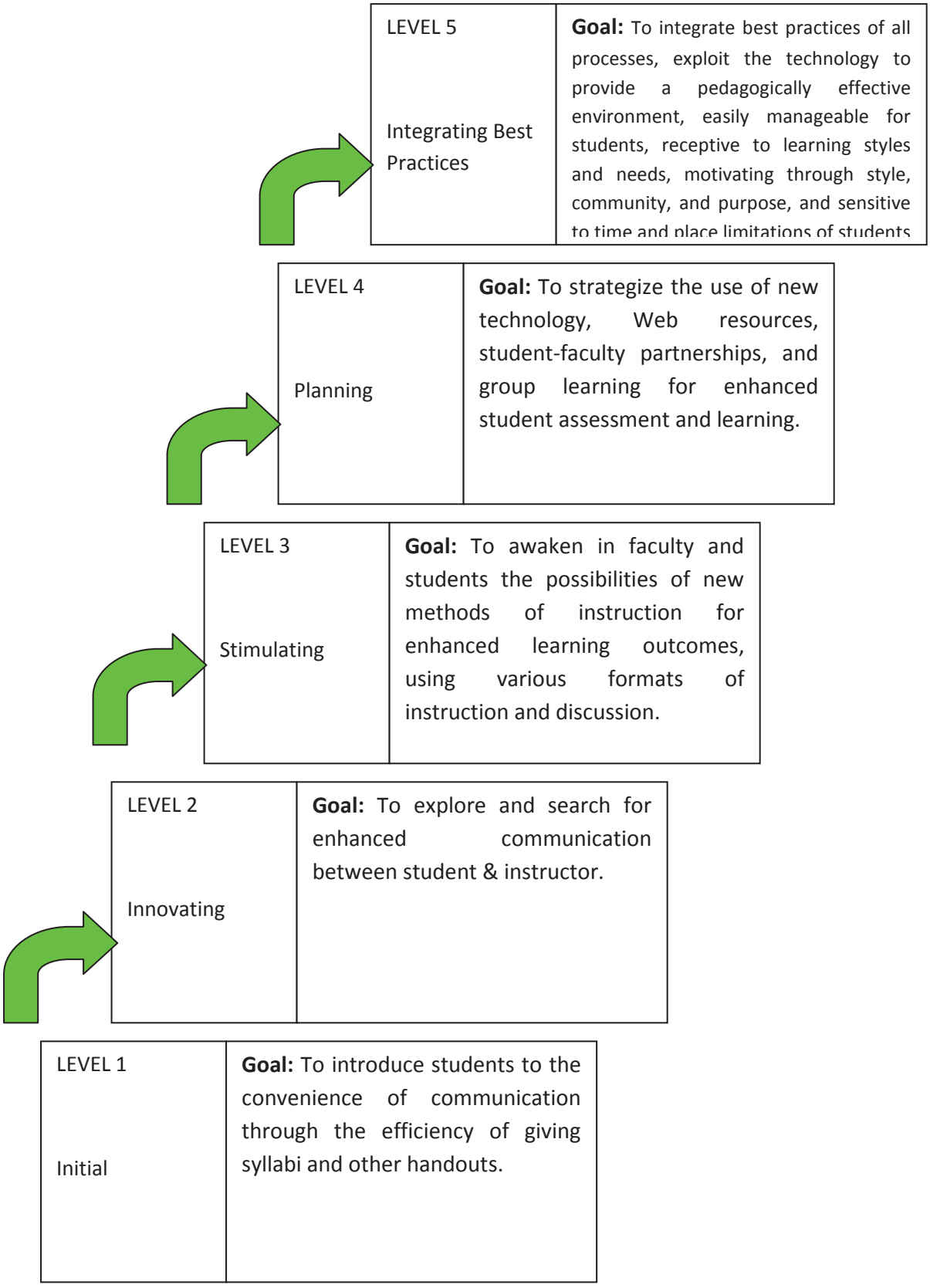
Figure 2. **Key process area goals by maturity level**



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EXPLANATION OF MATURITY STAGES OF HECMM

Level 1-Initial

At this level few processes are defined. Productivity and quality vary. Success depends on individual effort. No formal plan for recourse creation. Identification of financial requirements is not adequate.

Level 2-Innovating

Policies and objectives exist for educational programs. Student and staff needs are identified and recourses are created, but each program is operated independent of other. Plans are developed for resources. Educational objectives are defined. Basic project management practices are adopted. A common infrastructure for quality is established. Basic level documentation exists for each degree program and course design. There are policies that guide the degree programs in establishing the appropriate management processes. The program planning and tracking are stable and earlier success can be repeated.

Level 3-Stimulating

A participatory culture is established and coordination of expertise among processes and knowledge areas are encouraged. An organization's vision and strategy for education is developed. Processes at educational and management levels are properly documented and are no more dependent on individuals. Staff development programs are implemented within each area and their specialization needs are identified. A comprehensive student support program exists at institutional level. A common database exists to save the intellectual property of institution. Basic data from projects is collected which is used for planning, establishing scope, providing resources and meeting commitments of future projects.

Level 4-Planning

The institution as a whole develops effective measurement practices. The major characteristic of this level is that detailed measurement programs for educational and management processes are established organization wide. A common database exists for the institution. The institution adopts a common approach for quality assurance for each program. Planning for each degree program is integrated at the institutional level.

Level 5-Integrating best practices

Here the organization becomes a learning organization. Continuous process improvement is adopted organization wide. The data, which is collected in previous stages, is used to analyze defects

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and their causes. Cost-benefit analysis is performed on new technologies. Such technologies and process improvements are included as ordinary business activities.

IMPLEMENTATION ISSUES

All the maturity models are meant for industrial or software sector. So they have their limitations when we apply them in educational sector. We incurred the following difficulties when tried to define CMM for educational sector:

• Every key process area in CMM has a set of goals and related activities. It is very difficult to translate every goal and practices of the respective process area for educational sector.

• Education sector is more complex and they have many objectives and purposes. So it is very difficult for a single model to fit nicely into educational sector.

• Some goals and activities of key processes present no added advantage for educational domain and therefore create only unnecessary complications and raise the cost.

• Emphasis on a lot of documentation is unnecessary in educational sector and creates only a bureaucratic bottleneck.

• Translation of nomenclature and terminologies of CMM models to convert for educational sector is not easy task.

Conclusion

We described a maturity model for computing education that is based on the well-known capability Maturity Model created by SEI. Although our approach is new and has not yet been validated, the model incorporates best practices, which are either based on common sense or have been successfully applied to other domains with similar motivations. Other best practices are supported by CS education literature, or are founded on our personal experience as lecturers.

We find that certain key practices of CMM like rigorous documentation and use of a measurement program seem even better suited for our purpose, as they occur naturally in the context of education. This mitigates the negative impact of bureaucratic overhead on our model, the main criticism about CMM. We plan to continue the research on CEMM and further elaborate and validate this maturity model.

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