

A MATURITY MODEL FOR HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

The adoption of business process improvement strategies is currently a concern of most organizations. The quest for the benefits of this improvement on resource optimization and the responsiveness of the organizations has raised several proposals for process improvement methodologies. These approaches differ both in the principles that support them, and in the specific area to which they are intended. However, proposals and results of scientific research on process improvement in higher education institutions, extremely complex and unique organizations, are still scarce. This research project intends to propose the extension of a process improvement model for this particular type of organization. We propose to undertake a review of process areas, goals and practices used in reference maturity models, such as Capability Maturity Model Integration or Business Process Maturity Model, to determine which ones apply to academic organizations and which should be included, adapted or deleted. The resulting maturity model will be further validated in a Portuguese higher education institution. This study is being developed under the University of Algarve Informatics Engineering Doctorate program.

Keywords: Maturity; Education; Process; Improvement

JEL Classification: I23

1. INTRODUCTION

Higher Education Institutions are complex organizations. Although being autonomous, they have to execute a number of functions and develop a variety of procedures, so as to ensure the fulfilment of its duties, which inevitably raise constant challenges. The number of functions they perform and the variety of procedures developed under its autonomy to ensure the accomplishment of all its duties, raise constant management and administration challenges. Difficulties on procedure systematization and on workflow analysis, evaluation, and optimization carry problems not only to management itself, but also to information systems design (Zacarias & Martins, 2011).

Although many of its processes may be documented, these organizations, as well as many others, do not have systematic ways to verify if the graphical descriptions or workflows models are actually pleased in the actual implementation of activities. This problem can jeopardize not only the result of these procedures but also the validity of the requirements of any information system that meets the need of automation.

It is common to find newspaper articles on Information Technology reporting information systems failures that have huge execution times and costs (Bill Curtis & Alden, 2007). While some of these failures can be attributed to technology issues, the causes of many of these failures come from the organization that requested the service. Many, or perhaps most of

these problems, stem from weaknesses in organizational processes that are the automation system target (Bill Curtis & Alden, 2007).

The need for process optimization is not an exclusive problem of academic institutions. Organizations in many different areas, aware of workflow optimization benefits on time and cost control, have adopted strategies and methodologies for process improvement.

Today we can find a broad range of process improvement approaches, distinct from each other, either on its principles and techniques, or on the target area on which the improvements are focused. The most common approaches were initially developed and applied to software development organizations (e.g., Capability Maturity Model (CMM) (SEI, 1995) and Capability Maturity Model Integration (CMMI) (SEI, 2010)). However, inspired by these, other methodologies have been created for wider fields of application, allowing other institutions to reap the benefits of these initial approaches (e.g., Business Process Maturity Model (BPMM) (OMG, 2008)). Others were created as extensions of the most recognized models (e.g., Safety and Security Extensions to CMMI (Bofinger, Robinson, & Lindsay, 2002; Ibrahim et al., 2004)) in order to meet the specificities of a particular business area.

This research project aims, through the analysis of different process maturity models and through the evaluation of specific, higher education features of institutions, to suggest an extension of one of these models to this type of organization.

The next section presents concepts and specific characteristics of academic organizations from the point of view of its process areas. Moreover, we define the concept of business process, describe the concept of organization, approach the specificity of academic organizations and its process areas, identify the concept of business process and explain the main approaches to process improvement. The following section analyses the main process maturity models and those proposed for the education field. Afterwards, we identify the research problem, outline objectives and present the future work.

2. ACADEMIC INSTITUTIONS AND PROCESS IMPROVEMENT NEEDS

Laudon and Laudon (Laudon & Laudon, 2007) consider two main approaches to the concept of organization: the behavioural and the technical. In the first perspective, the organization is a balanced collection of rights, privileges, obligations and responsibilities. Individuals in these organizations develop their own ways to do their work, create ways of social networking and informally agree with their superiors and subordinates regarding ways, deadlines and conditions for the development of their tasks. Most of these agreements are obviously not documented, because they are informal. From the technical perspective, an organization is a social structure that receives formal and stable environment resources and processes them to produce outputs, which may be products or services. Capital and labour are the primary factors of production provided by the environment. The organization transforms these inputs into products and services in a production function. These products and services are produced by the environment in exchange for inputs. The set of procedures to organize the sequence to transform inputs into outputs are called business processes (Laudon & Laudon, 2007).

Higher Education Institutions are complex organizations with multiple power decision centres that bring together a wide range of heterogeneous interests. Mintzberg (Mintzberg, 1999), on his classification of the organization's structural configurations, places universities in the Professional Bureaucracies group, i.e., in the not centralized bureaucratic organizations group. In these organizations, the work developed by professionals is complex and standardized, predictable or predetermined. However, "in the Professional Bureaucracy,

often coexist two parallel hierarchies: one for professionals, directed upside, the democratic, and another to the functions of logistics support, directed downside, with the characteristics of a Machine Bureaucracy” (Mintzberg, 1999). This configuration is characterized as very dependent on the hierarchical structure defined in institutional organization, in which information flows are regulated and always run through the organization in a formal way. This model is based on work processes standardization in which all individuals have their roles rigidly defined.

The amalgam of functions and the required proximity to the students make the professionals of these organizations (the teachers) benefit from considerable autonomy. The professionals’ autonomy, coupled with the diversity of services and departments that integrate these institutions, make these structures very decentralized which hinders the formulation and adoption of comprehensive strategies and may increase the inertia of this type of organization.

In a professional bureaucracy, the flow of information between professionals is scattered and less formal. Various subsystems coexist in this type of organization, and there are a number of contact points with the central system. As a consequence, information flows are complex and not very systematic and structured. In the administrative structure, organized in a centralized bureaucracy with formalized procedures, the flow of information is more defined.

Within a single organization we can thus identify two structures with totally different attitudes regarding its information management: the first is a frame of teachers, which presents a decentralized structure with poorly defined information flows; the second is a centralized and formalized administration support. The definition of strategies for the management and optimization of processes must be different in each scenario.

Portuguese higher education institutions develop a diversity of functions, some of them connected but quite distinct. These functions include degrees and the completion of other courses, educational environment creation, research and scientific support, knowledge economic valuation and transfer, vocational training, community service, cultural exchange and cooperation with other national and international institutions, contribution to international cooperation, rapprochement between peoples, production and dissemination of knowledge and culture.

To comply with this multiplicity of functions, these organizations have a statutory, educational, scientific, cultural, administrative, financial and disciplinary regime which results in a variety of institutional organizations, also enshrined in the statutory scheme that fits these organizations. Universities and polytechnics can integrate autonomous instruction and research units, research facilities, libraries, museums and others. Any approach aimed at assisting these institutions in improving or optimizing their workflows must take into account the special characteristics of such organizations and the specific areas in which they are involved.

2.1 Business areas of Portuguese higher education institutions

An approach that intends to enhance process improvement in academic institutions has first to ascertain on which specific areas these organizations focus their activity. A first analysis of the academic institutions’ business areas can be made from a survey of the features of information systems used by Portuguese and foreign universities. The modules that integrate these systems may allow us to assess areas or large groups of business processes in which these organizations engage. In this section we analyse the FenixEdu system, developed and used by Instituto Superior Técnico (IST), and SAP Student Life Cycle, recently acquired by the University of Algarve and PeopleSoft Enterprise Campus Solutions, developed and marketed by Oracle. Various universities around the world use the two latter systems.

The three information systems presented, although showing its functionalities are organized and distributed in different forms, meet many of the same core business areas that are common to all higher education institutions:

- Student admission which manages student applications, admission and enrolment;
- Pedagogical management, that deals with specific aspects of teaching and learning course content;
- Assessment management, related to the processes of launching and monitoring student's classifications;
- Monitoring registration of student course progression;
- Fee payment;
- Course change and transfer management, which may include equivalence processes;
- Scientific activity management;
- Scholarships management;
- Human resource management;
- Physical resources management;
- Financial management;
- Internal Assessment which, besides the internal evaluation process, may include alumni monitoring;
- Community Relationship.

This analysis, though simple and lacking validation and further development at a later stage, shows that the areas in which higher education organizations engage are unique. This is the set of areas that will have to be addressed in order to improve operating processes in academic organizations, i.e., the activities in each of these areas that should be targeted for optimization in such organizations.

3. PROCESS MATURITY MODELS

How can we describe what a process is? There are various process definitions. Different disciplines characterize this concept in different ways, depending on the type of approach. In the context of information systems, the business process is the set of procedures or ways to organize the sequence for transforming inputs into outputs. This concept can be defined as how an organization coordinates and organizes a range of work activities, information and knowledge in order to produce a particular product or service (Laudon & Laudon, 2007) or simply as a set of tasks or activities performed to achieve a specific purpose or a particular result (OMG, 2008).

Process capability is the process measurable achievement outcome. An organization's process capability helps to predict the possibility of a project to achieve proposed goals. Projects undertaken by organizations with low process capacity cause large variations in costs, time, features and quality (Ibrahim et al., 2001).

Process improvement is a systemic approach that helps organizations optimize the sequence of activities so that they may improve their results. There are several approaches to process improvement. Kulpa and Johnson (Kulpa & A., 2008) summarize the existing approaches into five categories: Business Process Reengineering, Benchmarking, Process engineering/workflow management, Reverse Engineering and Model Based Process Improvement. The approach of this research is the Model Based, similar to other studies already developed in an educational context (e.g., Computing Education Maturity Model (Lutteroth, Luxton-Reilly, Dobbie, & Hamer, 2007), E-Learning Maturity Model (S. Marshall & Mitchell, 2002, 2003; Stephen Marshall & Mitchell, 2004; S. Marshall & Mitchell, 2006a, 2006b, 2008, 2009; S. J. Marshall & Mitchell, 2005, 2007)).

From a software development perspective, the capability maturity of an organization is defined as the power to “meet the demands of its customers in a reliable and repeatedly way” (Poppendieck, 2004) or as the degree to which an organization has established its procedures in order to repeatedly offer their clients high quality software within a given budget and timeframe (Chrissis, Kourad, & Shrum, 2003).

Maturity models are evolutionary roadmaps to the implementation of certain practices that are vital for one or more areas of an organization’s processes. Maturity levels guide the evolution of an organization from a state in which practices are poorly defined and incoherent to a level of innovation and continuous optimization (OMG, 2008). Capability maturity models are focused on improving processes in an organization. These models contain the essential components that effective processes must include for one or more disciplines and describe an evolutionary improvement path from immature or ad hoc processes, to mature and disciplined processes, with improved quality and efficiency (Chrissis, et al., 2003; SEI, 2010). These models allow us to evaluate the maturity level of an organization and, from there, develop a route for improving the capability of their processes.

Capability maturity models are repositories of practices that have proven effective through extensive application in industrial and government organizations. Organizational performance can be measured and improved, by comparing institutions’ practices with the essential practices contained in the models. Capability maturity models describe the key elements of an effective process for a particular discipline and the phases through which the processes can be established, implemented, evaluated and improved (Ibrahim, et al., 2001).

Capability maturity models are associated with one or more evaluation methods that help determine the ability of current processes and define the most critical issues for improving process quality and effectiveness (Ibrahim, et al., 2001).

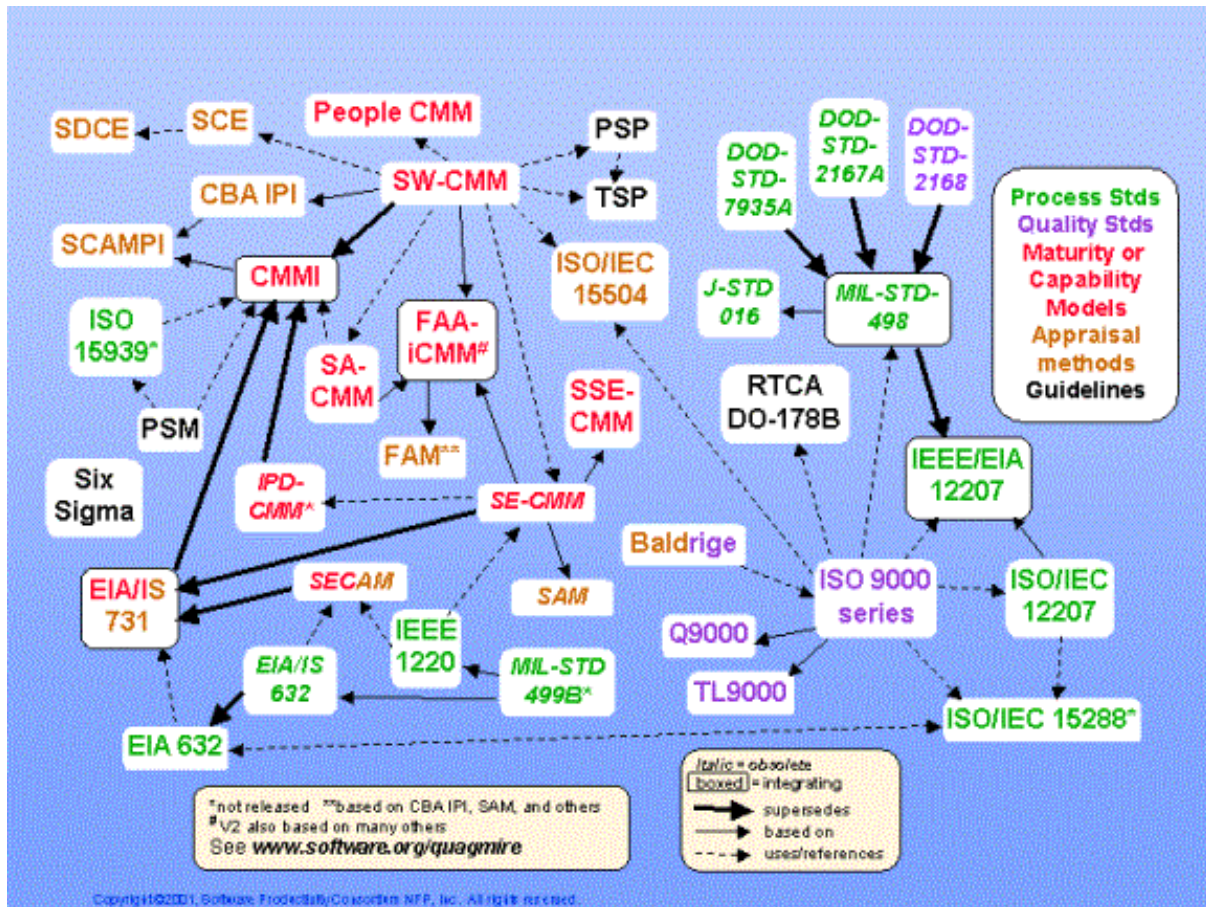
Capability Maturity Model Integration (CMMI) takes advantage of the guidance models geared to a single discipline (such as software and systems engineering), relates these disciplines, removes redundancy and integrates best practices into a common reference model, with common structure and terminology. An integrated capability maturity model can be used across different subjects (Ibrahim, et al., 2001). Maturity level refers to the performance state or degree that can be expected in an organization, in terms of its process capability (SEI, 2010).

3.1 Process Maturity Reference Models

The number of standards, recommendations, maturity models and other frameworks for process improvement that have been developed and then promulgated by governmental and trade organizations has hindered the selection of the best approach for an organization to improve their processes. In 1997, the Software Productivity Consortium created a Web page to help organizations understand which were the most important and how they related to each other. In 2001, Sheard (Sheard, 2001) updated this information and divided the approaches in categories: Maturity Models and Guidelines, Software Standards, Integrated Maturity Models, Systems Engineering Capability Models, Systems Engineering Standards, Measurement Standards and Quality Standards.

Figure 1 is an excerpt from Sheard’s scheme (Sheard, 2001) that shows the relationships between models, standards and assessment systems. Software standards were withdrawn from the original figure since they are not the main focus of this investigation.

Figure 1 - Excerpt from Sheard's frameworks quagmire (Sheard, 2001)



Sheard, S. A. (2001). Evolution of the frameworks quagmire

Sheard considered that the most important maturity models were the Capability Maturity Model (CMM), for organizations, and the Personal Software Process (PSP) and Team Software Process (TSP), for project development. All these models were developed by the Software Engineering Institute (SEI) in Carnegie Mellon University. The integrated models mentioned as the most important were Capability Maturity Model Integration (CMMI) also developed by SEI, which evolved from CMM, and FAA-iCMM, an integrated version of CMM developed by United States Federal Aviation Administration.

3.1.1 Capability Maturity Model Integration

CMMI is considered integrated, since it contains the necessary practices to maturity in various disciplines: Systems Engineering, Software Engineering, Integrated Product Development and Supplier Sourcing and Process. Currently, the CMMI has three versions: CMMI for development, focused on product and service development; CMMI for Services, directed to the processes of service organizations; and CMMI for acquisition, centred on acquisitions and supply of goods and services from others.

Process areas concerning organizations' generic processes are common to all versions. Process areas that differ from version to version are related to the business area to which each version is dedicated.

Each specific goal describes the characteristics that must be present for proper implementation of a process area. They are necessary to determine whether a process area is really implemented. A generic goal describes the characteristics necessary to institutionalize the processes that implement a specific process area. Specific practices and generic practices

are descriptions of activities considered important to meet specific and associated generic goals. Specific and generic practices describe the activities expected in order to meet the specific and generic goals of a process area.

These models have two representations: the continuous and the staged. The first allows the focus on specific processes that are considered important for the organization's immediate goals. The second allows the application of a standardized sequence of improvements that may serve as a basis for comparison regarding the maturity of different projects and organizations.

Table 1 - Comparison between CMMI representations

Level	Continuous representation Capability levels	Staged representation Maturity levels
0	Incomplete	
1	Executed	Executed
2	Managed	Managed
3	Defined	Defined
4		Quantitatively managed
5		In Optimization

Continuous representation establishes four capacity levels for each defined process area: Incomplete or Ad-hoc, Executed, Managed and Defined. In this representation, each process is analysed individually. The same organization can have coexisting processes with very different capability levels, since the analysis is performed independently for each process. This representation is used when an organization wants to achieve capacity levels in specific processes.

A process in level 0, Incomplete, is a process that does not run or runs partially. One or more specific objectives of the process area are not satisfied, and there are no general objectives, since incomplete processes are not institutionalized.

At level 1, the process is Implemented or executed, i.e., fulfils the tasks necessary to produce the result, and the specific goals of the process area are satisfied. However, the improvement achieved in this level may not be repeated in time if not institutionalized (if level 2 and 3 generic objectives are not reached).

At capacity level 2, the process is managed, i.e., is planned and executed in accordance with a policy. It employs staff with expertise to implement it and has the resources to produce controlled results. It involves relevant stakeholders (interested parties) and is monitored, controlled, reviewed and evaluated to ensure compliance with the process description.

A process in level 3 is a defined process, i.e. a managed process adapted from standard procedures according to the organization adjustment lines and its description and is maintained. At this level, the standards, process descriptions and procedures relative to a project are tailored from the set of organization standard processes to fit a particular project or organizational unit, in particular; therefore, they are more consistent, except for differences permitted by the adaptation guidelines. At this level, processes are usually more rigorously described than in capacity level 2. A defined process clearly states the purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs and exit criteria. At capability level 3, processes are more proactively managed, based on understanding of process related activities and process detailed measures, its work products and services.

The scaled representation, or maturity centred, establishes five maturity levels for classifying organizations: Initial, Managed or Repeatable, Defined, Quantitatively Managed and Optimization. Each maturity level sets objectives and practices that the institution should develop in each process area to be considered at that level. An organization is considered at a given level when the objectives of that level and all previous levels have been reached. For an organization to obtain a certain level of certification, it is necessary that all processes reach this maturity level.

At maturity level 1, processes are usually ad hoc. Organizations positioned at this level do not provide a stable environment to support processes. Success depends on the competence and the heroic efforts of the people and not on the use of proven processes. Despite this chaos, organizations in maturity level one can often produce products and services that work, though they often exceed budgets and fail to meet deadlines. Organizations at this level of maturity are characterized by a tendency to commit beyond their capacity, abandon processes in times of crisis, and for being unable to repeat their own successes.

At maturity level 2, the organization has to ensure that all processes are planned and executed in accordance with policy. They employ experienced and adequate resources to produce controlled outputs. All processes involve relevant stakeholders and are monitored, controlled, reviewed and evaluated to determine conformity with the process description. The procedural discipline reflected by maturity level 2 helps to ensure that existing practices are retained during times of stress. When these practices are in place, projects are performed and managed according to their documented plans.

At this maturity level, the status of the work products and service delivery are visible to management at defined points (for example, major milestones and completion of major tasks). Commitments with relevant stakeholders are established and revised as required. The work products are appropriately controlled. The work products and services satisfy processes descriptions, standards and specified procedures.

At maturity level 3, processes are well characterized and understood, and they have defined standards, procedures, tools and methods. The organization standard process set, which is the basis of maturity level 3, is established and improved over time. These standard procedures are used to establish uniformity within the organization. The processes of a project are defined by adaptation to the set of standard processes according to the organization's adaptation guidelines. At this maturity level, processes are typically more rigorously described than at maturity level 2. A defined process clearly states the purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs and exit criteria. At maturity level 3, processes are managed more proactively, based on understanding process-related activities and process-detailed measures, its work products, and services.

At maturity level 4, organization and projects establish quantitative, quality objectives and process performance, using them as a managing criterion. Quantitative objectives are based on the needs of customers, end users, organization and the ones accountable for processes' implementation. Quality and process performance are understood in statistical terms and managed throughout process life. Some sub-processes are selected for detailed performance measurements, statistically analysed and stored in an organization measurements database to support decision-making. Special causes of variations in the processes are identified and the sources of these causes are corrected to prevent recurrence. At this level, process performance becomes quantitatively and qualitatively predictable.

Maturity level 5 focuses on continuously improving process performance through incremental process improvements and innovations and technology. Quantitative process improvements are established for the organization and are continuously reviewed to reflect changes in strategic goals and then used as criteria in managing process improvement. Effects of deployed process improvements are measured and evaluated against the quantitative

process improvement. Both defined processes and standard processes are submitted, measurable, improvement activities. An important distinction between the maturity levels 4 and 5 relates to the type of process variation. At maturity level 4, organization is concerned with treating special causes of process variation and achieving statistical predictability of the results. Though processes may produce predictable results, the results may be insufficient to meet the targets set. At maturity level 5, the organization is concerned with treating common causes of process variation and promoting changes in the process (moving average process performance or reducing the observed process variation) in order to improve process performance and meet quantitative process improvement targets.

Organizational process maturity certification is not directly made through CMMI. The organization is evaluated using a specific method and receives a score of one to five. The score corresponds to the level of maturity where the organization is positioned (in staged representation); alternatively, it may refer only to isolated process areas, instead of maturity levels. In this case, processes are classified according to capability levels (continuous representation).

SCAMPI method (Standard CMMI Appraisal Method for Process Improvement) (SEI, 2001) is the assessment method for SEI's official classification of organizations. SCAMPI allows the processes' strengths and weaknesses to be identified and reveals the risks of developing or acquiring, while enabling the determination of capability and maturity levels.

3.1.2 FAA-iCMM

United States Federal Aviation Administration (FAA) Capacity and Maturity Model resulted from the need for strict procedure control to ensure the safety of 2 million passengers in about 30 000 daily commercial flights and 35 000 daily private flights (Ibrahim & Pyster, 2004). Given the inability of other models to meet all the needs of a system with so many disparate needs, FAA developed the ICMM (Ibrahim, et al., 2001) which integrates the principles and practices of 10 other models and standards: ISO 9001, ISO / IEC 12207, ISO/IEC 15288, ISO/IEC 15504, Malcolm Baldrige National Quality Award Criteria, EIA 731, CMMI, Software Acquisition CMM, CMM for Software and Systems Engineering CMM (Ibrahim, et al., 2001).

The maturity assessment method associated with this model is FAM (FAA-ICMM Appraisal Method). The method consists of 20 procedures organized in three phases: evaluation planning and preparation, results assessment and report. It involves interviews and documentary analysis, among other data collection techniques. Assessments are always conducted by external entities and organizations can focus only on a unit within a project, program or line of business or can involve all business processes of the company. This model will not be considered in this study, since there are no records of its use outside FAA companies.

3.1.3 Business Process Maturity Model

In 2008, Object Management Group (OMG) published process maturity model, based on CMMI principles called Business Process Maturity Model (BPMM) (OMG, 2008).

Although this model can be mapped to CMMI, it presents substantial differences. BPMM is geared towards the improvement of larger transactional business processes, for instance those constituting workflows that stretch beyond the boundaries of the organization, while opposed to project-oriented CMMI, which is more circumscribed (Bill Curtis & Alden, 2007).

BPMM includes five maturity levels that represent degrees of organization transformations to improve its processes. The sequence of steps is ordered so that each level provides the basis from which improvements can be triggered to operate at the next level. It allows the

identification of deficiencies in the processes of an organization and guides the improvements through logical and incremental steps (B. Curtis & Alden, 2006).

At level 1, Initial, an institution's practices and business processes are conducted inconsistently and sometimes in an ad-hoc mode. The results of processes are difficult to predict. Employees are often overworked, because management does not assign tasks evenly or does not provide the necessary resources for the implementation of activities. Management focuses on immediate case resolution, often hastily, and does not provide a stable work environment that allows the execution of tasks in a professional and disciplined way. Organization achievements are more due to heroic individual efforts than to an official set of sustainable processes.

At level 2, Managed, an organization uses forms of activity stabilization within each work unit to ensure that tasks can be performed repeatedly and so fulfil the essential obligations of each working group. The main concern in this level is management control over work units' environment to ensure that people can carry out their activities in a repetitive way and that are based on procedures that they are capable of performing. However, different work units can perform similar tasks through different procedures. The activity stabilization is still local; that is, the patterns are not yet established at the organization level. At this level, processes are defined concerning the current situation; that is, according to the way that each group conducts each process. This setting allows the identification of the best practices conducted by each working group, the analysis of the differences in the methods and procedures, the evaluation of the results and the assessment of the degree of commitments' fulfilment.

At level 3, Standardized, standard processes are developed and formalized from best practices identified in the various working groups. Best practices that were identified at the local level, i.e., those that achieved the best results, are adopted in all units and are also incorporated into other practices, from external sources, to address identified problems. The implementation of common processes allows the organization to control and monitor these processes, evaluate performance, learn and share knowledge and develop common skills. Standard processes' adaptation guidelines are provided when it is necessary to apply them in different situations and business needs. Experiments using standard procedures serve as a support for learning and apply to other processes.

At level 4, Predictable, the main objective is to develop the ability to predict the results throughout the workflow, in order to understand and control the variations, so that the results of the process can be predicted from intermediate states. To make this possible, the organization endeavours to establish a statistically stable process, whose results can provide good indicators for predicting the final results. The use of common processes allows the reuse of knowledge, experience and artefacts produced in various business processes. Thus, conditions are set for effective knowledge management, i.e., the capacity to reuse what was learned and developed in different situations. The foundations of knowledge management have been built over the previous levels of maturity. The standardization that took place at level 3 allows the inclusion, in the fourth level, of a set of functional processes in unique and integrative workflows. This reengineering often powers extraordinary opportunities to make processes more efficient.

At level 5, Innovative, proactive and opportunistic improvement actions are developed in order to seek innovations that can bridge the gap between the current capacity of the organization and the capacity needed to achieve business goals. Predictability obtained at the fourth level may still not achieve the desired results of business processes. In this level, proactive activities are triggered to allow raising the capacities of different processes in order to achieve the capacity that will accomplish the desired objectives. Continuous improvement is institutionalized and change management becomes a habitual and encouraged process in

the organization. Emerging changes are evaluated continuously to avoid a negative impact on performance or resource consumption.

BPMM features 30 business areas. Maturity levels 2 through 5 are composed of process areas, varying in number from level to level which, collectively, allow the achievement of its level capability. Each process area aims to achieve development goals, support or maintenance of the desired features for this level. Each process area consists of an integrated set of best practices that indicate what should be done but not how it should be done. As such, organizations are free to set their own methods and approaches to meet the goals and objectives of each process area.

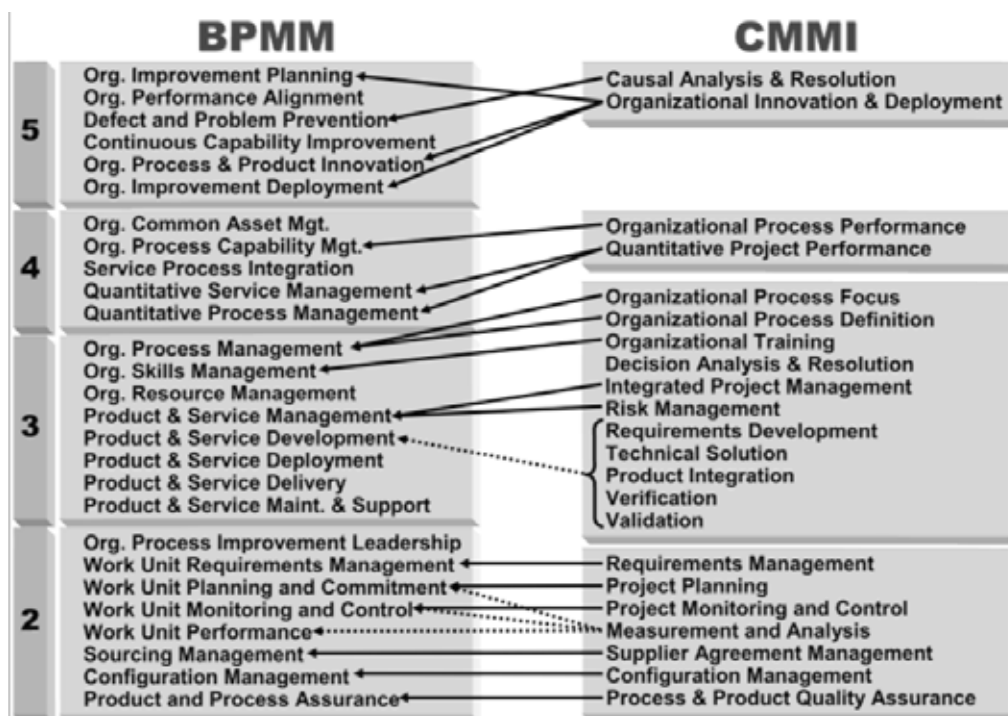
BPMM provides four ways for assessing an organization's BPMM compliance: Initial Assessment, a short procedure with reduced costs that only allows a general compliance review; Progress Assessment, which investigates all process areas and practices in order to determine maturity achievements within a maturity level or to anticipate the results of a confirmatory evaluation; Supplier Evaluation, which takes place during supplier selection and is identical to a progress assessment but does not include organization members' evaluation; and, finally, Confirmatory Assessment, which is a lengthy and thorough investigation of all process areas and practices within the evaluated maturity level.

The presented capability and maturity models have very similar characteristics. Since the three models were developed from the same principles, the maturity levels proposed are identical.

Although different, the three models base their approach on the adoption of best practices to achieve certain goals, grouped into process areas that vary in number, from maturity level to maturity level, and have similar ways to evolve from one maturity level to another. All featured models include one or more associated assessment methods.

The differences that stand out relate mainly to the content of the process areas proposed in each model, i.e., to the goals and practices defined for each maturity level, and to the way these goals and practices are grouped into process areas.

Figure 2 - Correlation between BPMM and CMMI, (B. Curtis, 2004)



Curtis, B. (2004). *Overview of the business process maturity model*

Still, it is possible to match the process areas of different models. BPMM process areas, for example, can be mapped to the ones suggested by CMMI. According to Curtis (B. Curtis, 2004), the contents of all SEI's model process areas are considered on one or more of OMG's model areas. Figure 2 presents a correlation between BPMM and CMMI process areas presented by the author.

Apart from process areas, the main differences between the models concern the structure of the paths that organizations have to travel to achieve higher levels of capacity or maturity. CMMI has two alternative representations: continuous and staged. The first allows capacity improvement in specific processes, and the second allows the improvement of all processes of an organization through maturity levels. FAA-ICMM and BPMM feature a single track, equivalent to the SEI's model continuous alternative. The concepts of goal and associated practices are also different between the FAA-ICMM and CMMI.

For CMMI and BPMM, specific goals describe particular characteristics that processes should have in order to meet the requirements of a process area. Generic goals describe the characteristics considered necessary to institutionalize the processes that implement a process area, i.e., for specific best practices to become routine and part of the institution's organizational culture. FAA-ICMM, rather than specific practices, proposes based targets that are considered fundamental to process execution. Generic practices, as well as describing the routines for process institutionalization, provide attributes that processes must possess so that their capacity can be improved.

Another important distinction has to do with the type of processes that are targeted to improve. BPMM is directed towards improving more transactional, business processes, involving workflows that go beyond the barriers of organization, unlike CMMI, which is oriented to defined projects (Bill Curtis & Alden, 2007). Curtis (B. Curtis, 2004) describes the BPMM not only as an evolution of the CMMI, in the sense that this was based on its principles, but also as a more comprehensive approach. While CMMI applies mainly to the development processes of software applications, BPMM applies to a broader spectrum of business processes and is therefore applicable to any business sector.

Although CMMI has been evolving in recent years, and each new update has presented innovations and different versions for different areas (development, acquisition or services), it is still a very generic model. Similarly, both FAA-ICMM and BPMM present general and abstract structures, ignoring certain business areas specificities. FAA-ICMM presents less detail on the engineering process areas of systems and its goals and practices. If, on one hand, the general and abstract approaches suggested by these models enable the use and adaptation to extended contexts and business areas, its application is limited due to the lack of suitability to some specific business sectors. Because of their unique characteristics and private purposes, these sectors cannot be addressed the same way as any other service organization or product manufacturer.

A maturity model adaptation or extension to enable process improvement in academic institutions requires, at first, the selection of one of these reference models. No records were found of FAA-ICMM use in companies outside the American Aviation Federation, and the model has not been updated since version 2, which dates from 2001.

Business Process Maturity Model seems to be more geared towards improvements associated with more organizational, transverse processes, making it more convenient for the alignment of management areas. In addition, the organizational perspective provided seems to be more interesting for the holistic improvement of an academic institution's business processes.

A staged representation of the Capability Maturity Model Integration for services also seems to be suitable for process maturity development in organizations that provide academic

institution services. Most maturity models' studies and proposals involving teaching and learning have been inspired by this model's principles.

3.2 Educational Maturity Models

The need to adopt process improvement strategies is also a global concern in education institutions. Over the past 10 years, some investigations have been conducted so as to focus on the search for maturity models in education.

White et al. (White, Longenecker, Leidig, Reynolds, & Yarbrough, 2003) launched the discussion about the applicability of CMMI to Information Systems Curriculum in the United States. The authors presented a proposal containing the features that educational institutions should develop, as well as a set of key process areas for each of the five levels of the CMMI maturity model, applied to the curriculum model: Level 1 - Initial; Level 2 - Repeated; Level 3 - Defined; Level 4 - Managed and Level 5 - Optimization. The model was supported by the major United States and international professional organizations like the Association for Information Systems (AIS), the Association for Computing Machinery (ACM) and the Association for Information Technology Professionals (AITP). It integrates a sequence of didactic units composed of objectives and specific content area. Each unit is defined by a set of skills that students must possess at the end of the courses, which are subject to measurement through mechanisms of evaluation and certification in the SI area.

Neuhauser (Neuhauser, 2004) presented a maturity model for online course design aiming to provide a tool to plan and evaluate these courses, based on a set of best practices. The proposed maturity model, Online Course Design Maturity Model (OCDMM), introduces in a phased manner a set of good practices at the institution and provides an integrated system for these practices to maturity since it guides the planner through best practices, learning principles, technologies, objectives and performance standards.

Just like CMMI, OCDMM provides a progressive procedure to transform face-to-face courses in online courses through 5 maturity levels or stages from Level 1, the initial level, where only e-mail and, occasionally, other online resources are used, to level 5, which integrates the best practices for implementing online courses. Each level includes 5 key process areas common to all levels: components (coverage) and appearance; individualization and customization; technology use; socialization and interactivity and assessment. Each of these areas contains a number of general guidelines and specific practices that distance-learning literature describes as being successful.

Thompson (Thompson, 2004, 2006) proposed a Learning Process Maturity Model (LPMM), based on CMM, to help students identify strengths and weaknesses in their learning activities and select the most appropriate strategies for learning. The author draws the parallel between software development and learning processes and presents a definition of maturity in the latter context, describing what may be a mature learner, based on education science literature. Levels presented in this model are similar to CMM. However, the model does not present key areas to consider, but just a set of skills that students should possess at each of these levels.

The Learning Process Maturity Model is still under development. The next step is the development of tools that allows students to transit between maturity levels.

Wang and Zhang (Wang & Zhang, 2007) proposed an IT service management model for Chinese universities based on ITIL (Information Technology Infrastructure Library). The authors present two reasons to justify the need to adapt the ITIL framework to higher education institutions: firstly, the existent model only provides a theoretical platform based on good practices and does not indicate ways for service development, since it has to be adapted to each organization's complexity; secondly, these models are oriented for commercial purposed organizations, the same way as the ones developed by Microsoft (Microsoft, 2011)

or HP (Hewlett-Packard, 2000), and not for higher education institutions, different in organization, culture and technology while having different recipients.

The research identified the differences between these IT systems and the discrepancies among commercial organization departments and university departments. From the comparison of these differences, the authors propose adapted models for organization, process management and technology in order to adapt the ITIL platform to the IT service management reality in Chinese universities.

Lutteroth et al. (Lutteroth, et al., 2007) proposed a maturity model for computer science teaching, also inspired by CMM, called Computing Education Maturity Model (CEMM), that helps computer science teachers by providing a set of best practices and strategies to improve teaching. The authors used the approach and the main concepts of CMM but did not follow it in detail, since they considered that it would not be possible to create a maturity model for education by pure analogy with the CMM. While CMM points out five stages for software project development, CEMM presents five stages for computer course development. The authors believe that, as the project in CMM, the course is a well-defined entity, usually with restricted costs and suffering few variations in time.

Dounos and Bohoris (Dounos & G., 2009) suggested the combined use of Total Quality Management (TQM) principles and the key concepts of CMMI for process improvement in higher education institutions. The authors suggest that TQM quality management principles, techniques used in industry and achieved benefits can be obtained in higher education institutions through the implementation of CMMI. At all five levels suggested in this model, the authors propose the use of TQM benchmarking techniques.

Marshal and Mitchel (S. Marshall & Mitchell, 2002, 2003; Stephen Marshall & Mitchell, 2004; S. Marshall & Mitchell, 2006a, 2006b, 2008, 2009; S. J. Marshall & Mitchell, 2005, 2007) proposed an E-Learning Maturity Model (EMM), also adapted from CMM. EMM divides an institution's capacity to support and provide e-learning into thirty-five processes, grouped into five broad categories or process areas: Learning, Development, Support, Evaluation and Organization. Processes are, however, inter-related through shared practices and different perspectives from five dimensions. Each process in the EMM is divided within each of these dimensions in practices that define how process results can be achieved by institutions. These practices are essential for processes to be successfully achieved, or they are simply useful for obtaining the particular process results. Practices are routines that define the fundamental concepts of different process dimensions. They are derived from empirical data resulting from scientific research in the e-learning field and from experts' opinions. These practices can be evaluated in the institutional context.

In this latest version, the authors proposed a method for the evaluation of processes in which the performance of each practice is rated on a 5-level scale from not suitable to fully suitable. Ratings are based on evidence collected by the institution to verify that the practices are being followed or not followed, to ascertain the quality as they are being performed, and to analyse the importance they have in the process.

After evaluating all process practices, a results average is determined, and a rating is assigned to each dimension. The proposed evaluation procedure identifies not only the degree of suitability of each dimension but also the practices that need to be improved. In his last job, Marshal and Mitchel mapped this assessment method to other guides and other sectorial and institutional standards for educational quality.

Petri, Garcia and Giraldo (Petrie, García, & Giraldo, 2009) proposed a model for higher education institutions certification, based on CMMI, to improve the capacity of processes in engineering and technology institutions, faculties and students. The authors tried to create a method to improve the levels included in engineering curriculum and in certification models to allow institutions in LACCEI (Latin American and Caribbean Engineering Consortium

of Institutions) to obtain accreditations and facilitate other accreditation processes. In the model proposal, Petri, Garcia and Giraldo include in each CMMI maturity level the documentation required for ABET (Accreditation Board for Engineering and Technology) accreditation. ABET is a U.S. organization that certifies higher education courses in applied science, computing, engineering and technology areas.

The model called Engineering Education Capacity Maturity Model (EECMM) uses the same levels of CMMI and identifies the capabilities and processes that are focused at each level of maturity.

Bass (Bass, 2010) developed a Maturity Model for Information and Communication Technologies in Educational Institutions in Developing Countries. The study aims to provide guidance for ICT infrastructure planning and to create a reference model to the necessary development phases for the efficient use of these resources.

This maturity model is based on documentary sources and on the analysis of a number of (Quintas & Gonçalves, 2010), colleges and universities in Ethiopia. Main documentary sources used were international benchmarks for ICT skills, such as International Computer Driving Licence (ICDL), European Computer Driving Licence (ECDL), scripts produced by Joint IEEE / ACM Computing Curriculum Task Force for Superior Education and Skills Framework for Information Age (SFIA), which provide a taxonomy that includes 86 ICT skill areas and a set of 290 associated tasks.

The proposed model consists of eight maturity levels, each identifying ICT infrastructure necessary to achieve institutional objectives and skills that students are expected to be able to develop at that level. To achieve a certain level of maturity, the institution should be able to achieve the objectives at lower levels. The model, which features eight levels of maturity, is not based on any reference to software development.

Table 2 presents the comparison of the educational maturity models described. Most models found are based on CMM or on the staged representation of CMMI. Although the various proposals intend to facilitate process maturity in different business areas, most of the presented models have the same five levels of maturity. They all suggest attributes that the organization should possess to be positioned at each stage. However, unlike the model in which they were based, most teaching maturity models do not explicitly identify any key process areas. Only the models developed by Dounos and Bohoris and by Marshal and Mitchel provide these areas as well as the methodologies and evaluation techniques to assess the fulfilment of requirements, to effectively place an organization in a certain level of maturity.

Moreover, the studied models give an insight of the processes of isolated business areas, i.e., they relate only to an informational entity such as the student, the course, the online course or the IT resource. None of these models present maturity practices that encompass the various entities or units, nor do they approach the processes that are crosswise to higher education institutions. On the other hand, most of the models present 'what to do', but none of them, perhaps with the exception of the model proposed by Duonos and Bohoris, presents 'how' an organization can effectively improve their processes allowing it to climb through the maturity ladder proposed. Table 3 synthesizes strengths and weaknesses of all the educational maturity models presented.

Table 2 - Comparison between educational maturity models

Model	Base	Business area	Levels	Process areas	Description	Improv. method	Assess. method	Focus
CMMI-ISC (White et al.)	CMMI	IS Curriculum	5	Variable number per level	Practices/ Features	-	-	IS Curriculum
OCDMM (Neuhauser)	CMM	On-line course planning and assessment	5	5 common to 5 levels	Practices/ Features	-	-	On-line course
LPMM (Thompson)	CMM	Learning	5	-	Skills	-	-	Student
ITIL-ITSMM (Wang e Zhang)	ITIL	Universities IT Services	-	-	-	-	-	IT services
CEMM (Lutteroth et al.)	CMM	Computer science teaching	5	-	Practices/ Features	-	-	Computer science course
CMMI-TQM (Dounos e Bohoris)	CMMI	Higher education institutions	5	-	Practices/ Features	TQM (Bench marking)		Higher education institution management
eMM (Marshall e Mitchel)	CMM/ CMMI	E-learning	5 dimensions	5 common to 5 dimens.	Practices/ Features	-	eMM Capability Assessment	On-line course
MRAIES (Petri, Garcia e Giraldo)	CMMI	Higher education institutions	5	-	Practices/ Features	-	-	Higher education institution management
ICTMMEI-DV (Bass)	-	ICT in education institutions	8	-	Practices/ Features	-	-	ICT Equip. and use

Table 3 - Strengths and Weaknesses of the educational maturity models

Model	Strengths	Weaknesses
eMM (Marshall e Mitchel)	Suggests attributes for an entity to be positioned in a specific maturity level; Methodology is based on a known and established reference model; Defines processes and groups them in defined process areas; Defines a set of good practices for each process to obtain success; Suggests an associated assessment method; Model has been continuously revised.	Focus on a specific entity: on-line course;
MRAIES (Petri, Garcia e Giraldo)	Process improvement is obtained in a staged, progressive way; Methodology is based on a known and established reference model; Suggests attributes for an entity to be positioned in a specific maturity level.	Doesn't present process areas; Levels are based on ABET specific requirements; Doesn't present maturity practices that encompass the various entities.
ICTMMEI-DV (Bass)	Improvement is obtained in a staged progressive way; Suggests attributes for an entity to be positioned in a specific maturity level.	Focus on a specific goal: provide guidance for ICT infrastructure planning in Educational Institutions on Developing Countries; Doesn't present process areas; Doesn't present maturity practices that encompass the various entities.

Model	Strengths	Weaknesses
CMMI-ISC (White et al.)	Process improvement is obtained in a staged progressive way; Methodology is based on known and established reference model; Suggests attributes for an entity to be positioned in a specific maturity level.	Focus on a specific entity: IS curriculum; Doesn't present maturity practices that encompass the various entities; Doesn't suggest ways to evolve from a level to another; The model has not yet been validated.
OCDMM (Neuhauser)	Process improvement is obtained in a staged, progressive way; Methodology is based on a known and established reference model; Suggests a set of good practices for an entity to be positioned in a specific maturity level.	Focus on a specific entity: on-line course; Doesn't present maturity practices that encompass the various entities; Doesn't suggest ways to evolve from a level to another; Model validation was obtained through the application of questionnaires to faculty representatives.
LPMM (Thompson)	Process improvement is obtained in a staged progressive way; Methodology is based on a known and established reference model; Suggests attributes for an entity to be positioned in a specific maturity level.	Focus on a specific entity: student learning skill; Doesn't present process areas; Doesn't present maturity practices that encompass the various entities; Doesn't suggest ways to evolve from a level to another; The model has not yet been validated.
ITIL-ITSMM (Wang e Zhang)	Suggests attributes for an entity to be positioned in a specific maturity level. Methodology is based on a known and established reference model;	Focus on a specific entity: university IT services; Doesn't present process areas; Doesn't present maturity levels or dimensions; Doesn't present maturity practices that encompass the various entities; The model has not yet been validated.
CEMM (Lutteroth et al.)	Process improvement is obtained in a staged, progressive way; Methodology is based on a known and established reference model; Suggests attributes for an entity to be positioned in a specific maturity level.	Focus on a specific entity: computer science course; Doesn't present process areas. Doesn't present maturity practices that encompass the various entities; Doesn't suggest ways to evolve from a level to another; The model has not yet been validated.
CMMI-TQM (Dounos e Bohoris)	Process improvement is obtained in a staged, progressive way; Methodology is based on a known and established reference model; Suggests attributes for an entity to be positioned in a specific maturity level; Suggests that the ways to evolve from a level to another should be based on benchmarking and Total Quality Management techniques.	Doesn't present process areas; Doesn't present maturity practices that encompass the various entities; The model has not yet been validated.

4. INVESTIGATION PROBLEMS

In order to limit the scope of this study and explain the major issues that this problem raises, this section identifies the research problems. The main problems identified were the following:

- The existing reference models have too broad of a spectrum, i.e., they are too general and ignore important, specific characteristics of higher education organizations, since they do not meet their business areas;
- The developed or adapted models in the educational field are focused on an isolated entity, sector or very specific business area, ignoring other academic institution areas;
- Most educational maturity models proposed do not suggest any process areas and its related goals and practices or the proposed process areas; goals and practices do not fit the reality of higher education institutions;

- The maturity models that focus on teaching processes do not give indications of ways of aligning the processes of management and administration of the institution with the processes related to the area of education that is the target of their attention;
- Existing reference models indicate which attributes an organization must show at each level of maturity and what best practices should be followed in each of them, but they do not indicate how they can or should be implemented so as to accomplish the improvement of processes within the organization.

This research aims to develop, adapt or extend one of the reference models presented in order to meet the following objectives:

- Review and compare the different, existing, business process maturity models and to highlight its inadequacy to the business areas of higher education institutions;
- Propose a business process maturity model which aligns management and teaching practices that coexist in academic institutions;
- Develop a set of new or adapted methodologies to provide ‘how’ an academic organization can improve its business processes, thus moving from one level to another in the proposed maturity model;
- Enhance the provision of educational maturity models;
- Validate the proposed maturity model in a typical, higher educational organization.

5. PRESENT AND FUTURE WORK

This work began with the study of the organizational structure of Algarve University, followed by the modelling of all business processes of one of its services - the Academic Services. Around fifty of the processes were analysed and modelled using Business Process Model and Notation (BPMN) (OMG, 2009) graphical representation. Process analysis enabled the identification of some improvement possibilities and demonstrated the variety of connections between this service’s sections and the links connecting them to the other units of the university and to outside entities.

The work also included the determination of the business areas within academic institutions, based on the review of the functionalities of three information systems used by Portuguese universities. The modules integrated in these systems, and the procedures they aim to systematize or automate, allowed the determination of a set of business process areas associated with these types of organizations. The analysis of FenixEdu, developed and operated by Instituto Superior Técnico (IST), Student Life Cycle (SAP), recently acquired by the University of Algarve, and PeopleSoft Enterprise Campus Solutions, developed and commercialized by Oracle, permitted the identification of 13 business areas: student admission; teaching/learning; student assessment; student progression; tuition management; student course change and transfer; scientific activity; scholarship; Human resources; physical resources; Finance; Internal Assessment and Community Relationship.

The methodology that will be used to create a maturity model suitable to these institutions is still being defined. However, it will necessarily include a more detailed analysis of the existing maturity models both for education and wider areas.

Finally, we propose to undertake a review of key process areas, goals and practices used in each model in order to determine which ones apply to academic organizations and which ones should be excluded, added or extended.

One possible approach is to select a set of well-defined informational entities that encompasses all the academic activities and to limit the analysis to each of them separately, as Lutteroth et al. (Lutteroth, et al., 2007) did with the *course* entity in CEMM.

The model validation will be developed at a later stage, through its application to two or more units of the same university, in order to verify the feasibility of its application, either individually or on the relationship between them. Alternatively, we can choose an approach based on informational entities, monitoring the use of the model on two defined entities to perform the validation.

This research is being carried out within the doctoral program in Informatics Engineering of the Electrical Engineering and Computer Science Department of the Science and Technology Faculty - University of the Algarve and is supervised by PhD Paula Ventura Martins.

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