

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/356436709>

DIMENSIONS OF A MATURITY MODEL FOR INFORMATION SYSTEMS IN HIGHER EDUCATION INSTITUTIONS

Conference Paper · November 2021

DOI: 10.21125/iceri.2021.0918

CITATIONS

4

READS

262

3 authors:



Rui Humberto Pereira
University of Maia

31 PUBLICATIONS 121 CITATIONS

SEE PROFILE



João Vidal de Carvalho
Polytechnic University of Porto

94 PUBLICATIONS 783 CITATIONS

SEE PROFILE



Álvaro Rocha
University of Lisbon - ISEG

457 PUBLICATIONS 5,257 CITATIONS

SEE PROFILE

DIMENSIONS OF A MATURITY MODEL FOR INFORMATION SYSTEMS IN HIGHER EDUCATION INSTITUTIONS

Rui Humberto Pereira¹, João Vidal Carvalho², Álvaro Rocha³

¹University Institute of Maia - ISMAI & Polytechnic of Porto / CEOS (PORTUGAL)

²Polytechnic of Porto / CEOS (PORTUGAL)

³University of Lisbon / ISEG (PORTUGAL)

Abstract

The complexity of the information systems (IS) in the higher education institutions (HEI) has been continuously increasing during the last decades. Thus, managers need tools to evaluate the maturity of their IS, in order to continuously improve them. Additionally, the accreditation processes and rankings may also include organisational aspects in their criteria, in which the maturity models may be a useful tool. However, the existing literature is scarce on validated maturity models focused on the comprehensive management of complex HEI information systems. In previous papers, we came to the conclusion of the need and opportunity to propose a new maturity model to evaluate the IS of HEI, as well as the methodology to follow in the development of such model. In the present paper, we discuss our proposal for the architecture of the new model, synthesizing the state of the model that we intend to develop. This proposal is based on a two-dimensional approach, composed by vertical and horizontal dimensions of information. We believe that our approach, can mitigate the implications of the complexly issues of HEI on the maturity model to be developed. This proposal is the result of a multicase study, in which we identified the dimensions to consider in the model. In the further steps of our work, we will validate each of one of these dimensions and define the set of characteristics for each stage of maturity.

Keywords: Stages of Growth, Maturity Models, Higher Education Institutions, Education Information Systems, Management.

1 INTRODUCTION

The complexity of the information systems (IS) in the organizations has been continuously increasing in the last decades. The higher education institutions (HEI) are not an exception. Due to the particularities in their numerous processes, the IS differ much from the others in common organizations. These systems must support the management of information in several and distinct domains, such as: academic organisation, financial, teaching, research, etc., with high level of requirements of internal and external interoperability. Additionally, during our research work, we observed that from one HEI to another the processes and concepts are very distinct.

All these observations allow us to argue that the HEI are very special in terms of complexity of management of IS, as well as the organization itself.

The Maturity models have been applied to the evaluation of IS and technologies [1]. The contribution of our research work consists on the development of a new maturity that could be applied by HEI managers to internally evaluate their information system, as well as externally by national and international agencies in terms of course accreditation and rankings.

In previous papers [2], we initiated our research by conducting a literature review that enabled us to identify the need and the opportunity to develop a new maturity model for the assessment of the HEI's ISs. Later, in another paper [3], we discussed and proposed the methodology to be followed in order to develop the model.

The present paper reports the current state of our project at the third step of Mettler's methodology, the design stage of the maturity model. At this stage of development, we adopted a multi-case study to interview a diverse group of seven IS managers from five Portuguese HEIs. The contribution of the present paper relates to a proposal for the architecture of a new maturity model and the identification of the dimensions that it should embrace, thus answering the research question RQ2, presented in Section 2.1. We should note that the initial research question, RQ1, was already answered in [2]. The results of this step of our work have great importance, because now we have the base conditions to start the design phase of the model. We should mention that we intend to develop a comprehensive maturity model, which is ambitious due to the complexity and number of dimensions. We argue that the proposed

architecture will facilitate this ambitious work, in order to systematically and gradually develop the model, dimension by dimension.

In the next section, we present the research methodology adopted in this step of our research work. Section 3 discusses the two-dimensional architecture that we propose for the new maturity model, as well as a short description of each dimension summarizing the collected data during the interviews. In the last section, we discuss the research findings and conclusions, pointing the suggestions for further work.

2 RESEARCH METHODOLOGY

In order to achieve the desired results for this step of our work, three aspects were considered cornerstones: the goals of research; the research methodologies; and the existing conditions for the realisation of this project (i.e., organisations and contacts available to collaborate on a project of this nature). As a result of this reflection and taking into account the research question and the goals established, it was decided to adopt an approach including the following methods: systematic literature review and design science research (DSR).

2.1 Research Questions

We initiate our work conducting a literature review. At the end of this first stage of our research work, it was considered opportune to initiate a research project that would contribute to an increase of knowledge on the maturity models applied to ISs of HEIs. Based on the initial description of the problem, the following research question was formulated in [2]:

RQ1 ► Is there a model, which consists of several maturity-influencing factors and maturity stages, that can be applied to ISs in HEIs?

In [2, 4] we reach the conclusion that there is no comprehensive and validated maturity model in the literature, thus answering this initial research question. Consequently, the following new question was formulated:

RQ2 ► What are the maturity dimensions associated with the maturity stages that are considered most important by the managers in the ISs of HEIs?

In order to answer question RQ2 presented here, a two-stage data collection strategy was adopted. In this paper, we discuss the first one adopting the case study methodology to identify the different dimensions (influencing factors) existing in the IS of an HEI. Subsequently, in a second stage we will adopt a survey to select, from the identified dimensions, the main ones to be considered in the IS of an HEI. We should note that in the present stage, primarily, we intend to present our proposal for the model's architecture while identifying those dimensions by means of the case studies. In the next stage, by means of a survey, to validate the collected data by means of as many contributions as possible.

2.2 Data collection - Multiple case studies

The case study was the chosen research methodology, since it utilises naturally existing information sources such as people and interactions between people within the scope of the case [5]. It is a research strategy that helped us to understand the phenomena in real-life situations [6]. Each HEI has its own reality in terms of strategic focus, organizational structure, processes and other issues. Thus, we considered important to consider as many as possible inputs for our study. The adoption of this methodology in our research project went through three steps. In the first one, we intended to ensure that the chosen strategy fits our previous methodological choices. It includes the definition of the nature of the investigation. Although case studies work very well in most different types of research, they can be used as both descriptive and explanatory research, because they allow us to explain why the phenomena are happening. They can be used also as exploratory research, because they can give us initial insights on the phenomena. At this stage of the development of our project, exploratory research can provide very important inputs to build the solid foundations for the model we intend to build.

In the second step, it was decided which type of case study we would adopt. In this phase we decided if we would apply it to a single HEI or to multiple HEIs. Our choice fell on the second option, as a unique case study would be very reductive, taking into account the different types of HEI in the higher education system. Thus, five Portuguese HEIs were chosen. In order to obtain a representative sample of the spectrum of higher education in Portugal, we included universities, polytechnics, public and private, as

well as larger and smaller institutions. We know how important it is for our sample to be generalised enabling that our findings to be applicable to any type of HEI. The purpose of this phase was to collect data to corroborate the findings of the literature review and to allow us to generate a theoretical framework. Our cases studies were based on semi-structured interviews with senior managers from those HEIs during the second quarter of 2020 (due to the pandemic situation, the later interviews were online through video conferences). Seven specialists from those five HEIs, all of them with more than 13 years of experience in IS management and/or development, were interviewed as part of the data collection process. The interviewees were asked questions from an interview guide, which included a request to the interviewee to identify IS dimensions that can be selected to assess the maturity of the IS of the HEI. The ethical guidelines suggested that all case studies should employ the practice of anonymising empirical findings.

The main outcomes of the first stage of data collection allowed us to generate empirical data about the current process, which will form the precursor to the development of a theoretical framework. Additionally, this allows the researcher to understand if a convergence or divergence of views exists between current practitioners in the research subject area and the findings of the literature review.

Finally, in the third step, we selected the depth of the present case study. In our research, we are only focusing on one part of the HEI: its information system (IS). Thus, the analysis of multiple HEIs was directed to their ISs and their more general aspects, such as their dimensions. We consider this approach, which circumscribes the boundaries of the present phase of our study, as the most appropriate to allow a more efficient comparison between the different cases involved.

2.3 Results – Data analysis

Data collected during the previous stage were analysed via content analysis, an objective and systematic form of data analysis applicable to analysing data such as semi-structured interviews [7]. Content analysis is a systematic data analysis technique that collates valid inferences from texts into fewer content categories based on explicit rules of coding and themes. Interview transcripts were transcribed in their entirety by the researcher into a document for each completed interview. Interviews were coded by the researcher to allow for analysis of interviewees' responses and to record information relating to the research questions. Although content analysis can be extremely time-consuming and laborious [8], and is reliant on the quality of information contained in the documents or transcripts [7], it is a transparent, flexible and systematic data analysis technique [7].

At the end of the interview process several dimensions were identified that are relevant to the management of the information of the studied HEIs. In the next section, we briefly discuss each of them, as well as how they are related.

3 PROPOSED APPROACH FOR THE MODEL'S ARCHITECTURE

3.1 Two-dimensional architecture

The development of a comprehensive maturity model it is an ambitious task, considering the diversity of processes, complexity issues of HEI and the lack of standards in their procedures and concepts. This was our earlier observations during the interview process and the further final analysis of each case study. Thus, an optimal architecture is crucial for the success of the model, pushing us forward to an initial decision regarding the best way of structuring the identified dimensions.

We observed that many of them are transversal to the organisation. These are cross-cutting activities to all the functional areas of the HEI, with more or less relevance. One example of these cross-cutting dimensions are the data analysis and reporting. In the scope of our model, we named these as horizontal dimensions, because they are transversal to the entire organisation, intercepting the vertical ones. On the other hand, in the proposed architecture for the new model, the vertical dimensions are top-down in the HEI and, in most cases, are associated with the functional areas in the HEI. These latter include the management of all information within a strict functional area, at all levels, in a vertical perspective. As examples, we give the academic and financial departments.

This approach, to mitigate the complexity problem of the new maturity model, enable us to propose a two-dimensional architecture, structured on vertical and horizontal dimensions, as depicted in Fig. 1. This architecture presents the different vertical dimensions that represent an extensive set of characteristics. Some of these characteristics are specific to each vertical dimension and others are

transversal (shared) characteristics associated with horizontal dimensions. These transversal characteristics belong to vertical dimensions and simultaneously to the horizontal ones, thus being shared by all vertical dimensions. In Fig. 1, vertical dimensions from 1 to N and horizontal dimensions from 1 to M are represented, taking into account that the number of vertical dimensions is not necessarily equal to the number of horizontal dimensions. The characteristics of each vertical dimension, regardless of whether they are exclusive or generic, will be grouped at different stages of maturity, depending on their nature (earlier or more mature). The analysis of all the characteristics of a vertical dimension, verifying its existence or absence, will make it possible to identify the stage of maturity associated with the HEI IS.

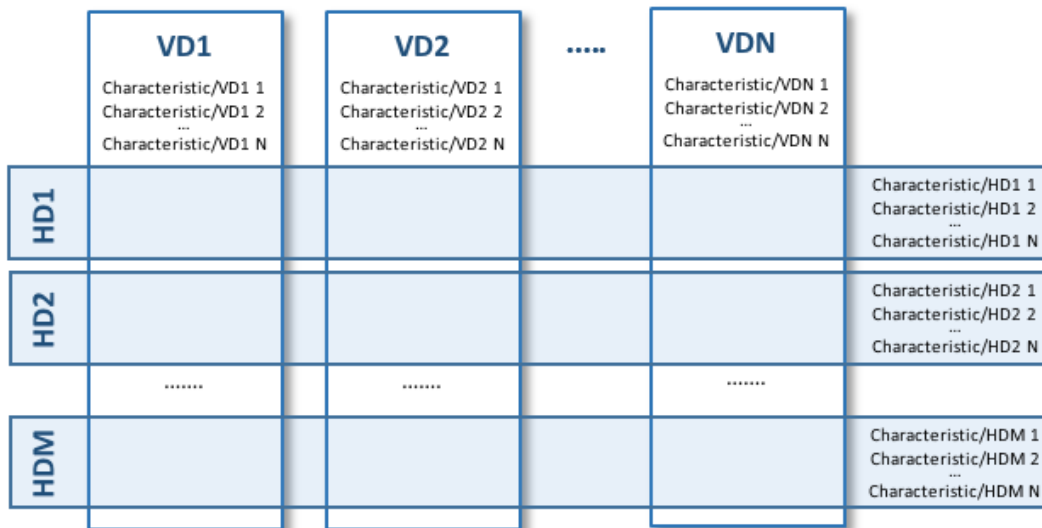


Fig. 1. Architecture of a Higher Education Institutions Information Systems Maturity Model

3.2 Dimensions of the model - Vertical and horizontal

As mentioned above, by proposing the vertical dimensions we intend to perform a segmentation of the IS according to the major HEI's functional areas. Thus, making easier the identification of dimensions and, in the future, the characteristics of each one of them. Additionally, this approach provides a top-down perspective of the IS in terms of its maturity, which is very useful for a departmental-based oriented evaluation of the HEI.

The vertical dimensions that were identified during the interviews are briefly discussed next:

- Vd_AM: Academic Management - This dimension includes the processes that relate to all administrative aspects of the students' life in the scope of their enrolment in the courses in one or more academic year;
- Vd_FM: Financial Management - This dimension encompasses all issues regarding accounting, treasury, budget control, expenses approvals, and all the other ones related with financial management and control;
- Vd_HRM: Human Resources Management - The human resources management includes the maintenance of personal data, of teachers, researchers and staff, salaries, career progression, hiring workflows and attendance control;
- Vd_TS: Teaching Support - in this dimension, all data regarding the teaching process is managed. Includes all processes that involve teachers, students and services (mainly the academic services);
- Vd_RM: Research Management - The research activities are an important and distinctive part of the HEI's mission. In recent years, the management of the current research information has attracted the attention of the academic community, leading to the emergence of the Current Research Information System (CRIS) [9];
- Vd_Com: Communication - The issues related with internal communication are complex to manage due to the large number of participants and the diversity of contexts, such as institutional

communication, course marketing, notifications to students about issues related with their enrolment, as well as notifications to members of the HEI about their contractual relations;

- Vd_Alumni: Alumni - In recent years, the relationship with alumni has gained relevance in the HEIs' strategies. This can be considered as a sub-department of Communication, but all the experts that we interviewed agreed that alumni have specific requirements in the managing of information;
- Vd_IR: International Relations - Information management related with student exchange programs, like ERASMUS. In this dimension we also include all issues related with the management of attracting new international students, besides the ones in exchange programs;
- Vd_PM: Project Management - This concerns the management of all information produced and consumed during the execution of projects with, or without, external stakeholders and funding, such as a new building on the campus;
- Vd_BM: Building Management - This dimension considers the management of all the information about buildings, laboratories and equipment;
- Vd_SS: Social Services - The Social Services are another relevant dimension in HEIs. Besides their particular requirements in terms of funding management, they have a strong proximity with the academic organisation.

As previously mentioned, the horizontal dimensions relate to cross-cutting processes and activities in all vertical dimensions. However, we note that some of them may not make sense in the scope of a particular vertical dimension. The main goal of this two-dimensional structure relates to the way that, in the future, our model will be applied. The maturity model that we intend to develop is ambitious in terms of complexity and coverage, since it intends to evaluate the entire information system of an HEI. Thus, this approach will facilitate our work in its next stage, enabling the systematisation of the observable characteristics of each dimension. Following this approach, we are convinced that a horizontal dimension can be evaluated systematically and coherently in the scope of all the vertical dimensions, as well as evaluated separately in the scope of the HEI.

- HD_DA: Data analytics - The set of capabilities of the platform to produce indicators and statistical outputs;
- HD_RT: Reporting tools - The set of capabilities of the platform to produce listings and exports;
- HD_WF: Workflow and Document Management - The capability of the information system (based on a monolithic application or several applications) to support the workflow of a process across several departments (i.e., several dimensions) and manage associated documents, regardless of the granularity and types of documents (files or data records);
- HD_INT: Interoperability - This dimension is concerned with the capabilities of interoperability with external systems;
- HD_SEC: Security - In this dimension it is intended to evaluate the capabilities of the platforms to ensure the security of data in terms of applied policies and the implemented mechanism, for instance, how is the access to the data of users, with distinct roles (student, teacher, coordinators and distinct functions of the staff) and times (e.g., the academic year), controlled;
- HD_UU: Usability and Ubiquity - These two aspects are relevant in terms of the productivity when using the applications. Thus, the presence or absence of these characteristics influences the maturity of the information system;
- HD_TI: Technological Infrastructure - The infrastructure that supports the applications has an impact on the applications in terms of performance, stability, reliability and scalability. Although these issues do not interfere with the number of features of the applications, or the quality of that data, they can compromise the HEI activities;
- HD_US: User Support - Like the previous dimension, the support for users has an impact on the optimal functioning of applications and, consequently, on the management of information. We were here again inspired by the literature [10] in proposing this dimension;
- HD_PS: Persons and Strategy - The persons are part of the information system. Thus, we are convinced that, in order to access the maturity of an IS, it is important to consider the characteristics of persons and their strategy and vision for their organisation. This dimension was obtained from the literature [10, 11].

4 DISCUSSION OF THE RESULTS AND FINAL REMARKS

Maturity models that effectively support the decision makers in the process of improving educational systems and supporting major organisational, procedural and digital transformation are very valuable. However, the existing literature is scarce on empirically validated maturity models focused on the comprehensive management of complex HEI information systems.

In this paper we report the current state of the development of a new maturity model tuned for HEI information systems. This maturity model is being developed in order to address the complexity of this type of organization aiming to offer a useful tool to HEI's managers. Additionally, we also are convinced that such model could also be applied by national and international agencies in course accreditation and rankings.

In order to achieve acceptance and recognition, both in the academic community and in society in general, we are conducting our work following a methodology for the development of maturity models, the Mettler's methodology [12]. Our work is now at that third step of this methodology, the design stage of the maturity model. At this stage of development, we adopted a multi-case study to interview a diverse group of seven IS managers from five Portuguese HEIs.

In the previous sections, our proposal for the architecture and dimensions of the new maturity model that we intend to develop was discussed. The proposed approach is based on a two-dimensional architecture with two types of dimensions: Horizontal and Vertical. This approach was corroborated by all the experts whom we interviewed, as well as the advantages that we identified relating to it. The proposed approach presents two main advantages: In the first place, it will enable the systematisation of all the common characteristics that must be evaluated in the scope of each vertical dimension. Consequently, this approach enables the coherence of the evaluation of the maturity of the HEI's IS in a top-down perspective in terms of the common characteristics, because they are considered in the horizontal dimensions. This is an important aspect, since permits that these characteristics could be shared by all of the vertical ones. In our opinion, this design option it will simplify the process of applying the maturity model, since enables the users to focus in a smaller set of characteristics.

As second advantage of the two-dimensional architecture, the proposed approach also enables other perspectives of evaluation. As example, please consider HD_RT - reporting tools. One can evaluate the maturity of the reporting capabilities in the restrict scope of a vertical dimension, for instance, in the VD_FM - Financial Management services, or transversally to the entire HEI. This features make the model flexible, because users can identify the IS's weaknesses, inside a module or service, or globally. We consider this aspect very relevant, because it is a common practice in the organizations to have distinct platforms for each service, attending to their specific requirements, regardless more or less interoperability among them.

In Section 2.2, we discussed our multi-case study presenting a set of dimensions that were identified, thus answering to the research question RQ2, formulated in Section 2.1. This early acceptance pushes us towards to the next development stage of the project in which the focus will be on the construction of an extended survey in order to select the main dimensions to be considered in the maturity model. This survey will be launched in the coming months to a diverse set of managers from several HEIs. In this next phase of our work, we will analyse the results of the survey in order to validate the earlier results obtained in the present multi-case study meeting the conditions to initiate the design of the first version of the model.

ACKNOWLEDGEMENTS

This work is financed by portuguese national funds through FCT - Fundação para a Ciência e Tecnologia, under the project UIDB/05422/2020

REFERENCES

- [1] Fraser, P., J. Moultrie, and M. Gregory, The use of maturity models/grids as a tool in assessing product development capability. In Proceedings of the IEEE International Engineering Management Conference (Cambridge, UK, Aug. 18-20). IEEE Engineering Management Society, Piscataway, NJ, . 2002: p. 244-249.

- [2] Carvalho, J.V., R.H. Pereira, and A. Rocha, Maturity models of education information systems and technologies: A systematic literature review. . In 2018 13th Iberian Conference on Information Systems and Technologies (CISTI). IEEE., 2018.
- [3] Carvalho, J.V., R.H. Pereira, and Á. Rocha, Development methodology of a higher education institutions maturity model. . In International Conference on Intelligent Networking and Collaborative Systems. Springer, Cham., 2018: p. 262-272.
- [4] Carvalho, J.V., R.H. Pereira, and Á. Rocha, A systematic literature review on maturity models for information systems in higher education institutions. *Innovations in Education and Teaching International*, 2019: p. 1-16.
- [5] Hyett, N., A. Kenny, and V. Dickson-Swift, Methodology or method? A critical review of qualitative case study reports. *International journal of qualitative studies on health and well-being*, 2014. 9(1).
- [6] Yin, R.K., *Case study research: Design and methods*. 2003. 5.
- [7] Bell, E. and A. Bryman, The ethics of management research: an exploratory content analysis. *British journal of management*, 2007. 18(1): p. 63-77.
- [8] Robson, C., *Real world research: A resource for social scientists and practitionerresearchers*. Oxford: Blackwell., 2002. 2.
- [9] EuroCRIS. Main features of CERIF. EuroCris - The International Organization for Research Information 2020 10/09/2020]; Available from: <https://www.eurocris.org/cerif/main-features-cerif>.
- [10] Solar, M., J. Sabattin, and V. Parada, A maturity model for assessing the use of ICT in school education. *Journal of Educational Technology & Society*, 2013. 16(1): p. 206-218.
- [11] Kenny, J., *Strategy and the learning organization: a maturity model for the formation of strategy*. The Learning Organization, 2006. 13(4): p. 353-368.
- [12] ISO9126-1. ISO/IEC FDIS 9126-1: Software Engineering - Product quality - Part 1: Quality model. 2000 Oct 2015]; Available from: http://www.usabilitynet.org/tools/r_international.htm#9241-11.