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Architecture of a maturity model for information systems in higher education institutions: multiple case study for dimensions identification

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Abstract

Higher education institutions (HEIs) are complex and dynamic organizations in terms of information management, forcing their information systems to respond to enormous challenges and threats. In order to evaluate the HEIs' information systems, we propose the development of a maturity model capable of supporting the role of HEI's managers, as well as accreditation agencies, in the assessment of the maturity of these systems, thus, promoting continuous improvement. In this paper, we present and discuss our proposal for an architecture of the maturity model being developed. This one is based on a two-dimensional architecture composed of vertical and horizontal dimensions. We selected a multi-case study approach, based on five Portuguese HEIs, and reviewed the literature to identify the dimensions. This case study was supported by interviews with experts from the selected HEI. The results of this research work were both encouraging and promising amongst the interviewed experts, revealing a high level of acceptance of the general model architecture, as well as positive expectations about its usefulness in the future. The development of our maturity model is carried out by following a formal methodology specially designed to support the construction of this type of model.

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1 Introduction

Maturity models achieved great popularity in the area of information systems (IS) and technologies when they were initially proposed for objectively evaluating the software development process, but over time, they have also been proposed both for the development of individuals and for the general evolution of organisations or the particular evolution of the IS management function. These models mainly differ in terms of the number of stages, variables of evolution and focus areas (Carvalho et al. 2016; Mettler and Rohner 2009; Rocha 2011). Each of these models identifies certain characteristics that specifically define the requirements of the next stage of growth. These types of models can be applied in the education sector in order to strategically plan for IS maturation, based on the degree of alignment between the educational organisation's (e.g. HEI) strategy and the selected growth path, as well as associated investments and improvement activities.

Higher education institutions (HEI) are complex organisations requiring equally complex information systems, which support their management of information in several and distinct domains, such as: academic organisation, financial, teaching, research, etc. In previous papers (Carvalho et al. 2018a), 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. We are convinced that such a maturity model can be a useful tool for HEIs, enabling the self-assessment of their IS. The national agencies of accreditation, as well as other types of national and international agencies, can also use this tool to evaluate the maturity of the HEI in terms of the quality of the management of information and the procedures.

As far as our knowledge, in the literature there no reference to a comprehensive maturity model that embraces the entire spectrum of dimensions in terms of the HEIs' information systems.

The Maturity Model for ICT in School Education (ICTE-MM) (Solar et al. 2013) has three elements supporting educational processes: information criteria, ICT resources, and leverage domains. Changing the traditional and exclusive focus on ICT, five leverage domains are defined: Infrastructure, Educational Management, Administrators, Teachers and Students. Despite its spectrum of coverage, this model does not explicitly considers issues such as business process definition/documentation and IS capability for supporting such processes. It is based on international standards for assessing the school's development regarding to the use of ICT and not a model for accessing the IS capability for supporting the school's management and teaching/learning processes.

The Capability Maturity Model for Quality Education (CMM-QE) (Manjula and Vaideeswaran 2012) is a framework for quality education assessment and process improvement with five maturity levels. The CMM-QE evaluates the education system engineering process from the multi perspectives of academic,

infrastructure, administration, facilities, etc. In the literature, this model is not clearly presented. Although a number of variables grouped in four measurement models covering several areas of the educational institution is referred, none of them have a concise and systematic description. Only an apparently unordered and unrelated list of characteristics is presented. In our point of view, this missing systematization of the assessed attributes compromises the reader's full understanding regarding the proposed authors' framework, as well as its applicability in the real world practice.

The Online Course Quality Maturity Model Based on Evening University and Correspondence Education (OCQMM; Gu et al. 2011) proposes to assess the quality of online courses in evening university and correspondence education. The OCQMM can guide the institutions that engaged in adult education to meliorate the implementary process, so that the implementation quality of online course will be improved. OCQMM divided online courses quality maturity in evening university and correspondence education into four maturity evolving ladder levels, each low-level is a basis that achieve a higher level. This model is focused in course quality, it does not consider facilities for students, administrative support or other specific IS aspects of HEIs.

The Maturity Model for ICT in Educational Institutions in Developing Countries (ICTMMEI-DV; Bass 2011) is a proposal 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. The model defines the ICT infrastructure resource levels required to achieve primary organizational objectives expressed in the form of student learning outcomes. The levels in this model show management, teaching and technical staff, as well as donors how to make most efficient use of ICT resources by maximizing opportunities for student learning. Despite the lack of discussion regarding those three important levels, we can conclude that this model is strictly focused on ICT. Additionally, was specially designed for education institutions of developing countries, in which the resources are very limited.

The Maturity Model for Online Education (eQETIC; Rossi and Mustaro 2015). It is a model capable of supporting steps that guide the planning, development, and maintenance of digital educational solutions. The eQETIC model follows a continuous process improvement approach, whereas the implementation of processes in a developer organization of these types of solutions favours the development lifecycle and the quality of these solutions. It is focused on the quality of the product development process, including the learning process, the environment and aspects that condition the success of the education institution in terms of quality of the specific scope of solutions (distance education, e-learning and learning objects).

After studying (Carvalho et al. 2018a) all the previously discussed related works, we come to the conclusion that there is no comprehensive maturity model that embraces all aspects of information management in HEIs, motivating us to initiate a research project that would contribute to an increase of knowledge on the maturity models applied to ISs of HEIs.

In order to develop a maturity model broadly accepted in the academic community and in society in general, in our research work we were greatly concerned with the methodologies and the scientific rigour that is being applied in the conception of

the model. Thus, in another paper (Carvalho et al. 2018b) we discussed the chosen methodology (Mettler's methodology 2010), which we are now following for the conception of our maturity model.

The present paper reports the current state of the development of the new model. Our work is now 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 RQ, presented in Sect. 2.1. This is an important step in our work, because it will allow us to systematically and gradually develop the new model, dimension by dimension, considering shared characteristics among them. We should mention that we intend to develop a comprehensive maturity model, which is ambitious due to the complexity and number of dimensions.

In the next section, we present the research methodology adopted in this step of our research work. Section 3 presents the proposed architecture for the new maturity model that is being developed, followed, in Sect. 4, by a discussion of the research findings in terms of the dimensions that compose this architecture. The paper is finalised with the closing remarks and suggestions for further work.

2 Research methodology

In the initial phase of this project, we reflected on three aspects 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).

In this research, through the literature review, it was sought to identify and discuss a set of concepts and key aspects related to the maturity models of the IS in the educational area, as well as to gather, analyse and systematise a set of contributions on the maturity models of the ISs in the HEI field in particular (Carvalho et al. 2019). In addition, we also analysed and summarised the different methodologies to develop a conceptual maturity model in the IS field. At the end of a systematic literature review, one of the most important results, in addition to a description of the state of the art on the maturity models of ISs in the educational field, the fact was identified that, as far as it was possible to know, there is no sufficiently comprehensive maturity model to characterise the ISs of HEIs. In relation to the other adopted method, this work used the DSR research methodology, in the framework defined by the guidelines of Hevner et al. (2004) and the methodology for the development of maturity models proposed by Mettler (2010), which is consistent with those guidelines. Regarding the activities of

the Mettler methodology adopted for the development of the maturity model, we find ourselves in phase 3 of this method, that is, Design model (Carvalho et al. 2018b).

2.1 Research questions

In the present paper, we intend to contribute to the increase of knowledge in the field, by answering to the following research question:

RQ ► *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 RQ, a two-stage data collection strategy was adopted. The first (in this paper) adopts 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, the case study, it is intended to identify those dimensions and, in the future stage, through the survey, to validate the collected data by means of as many contributions as possible.

2.2 Data collection: multiple case studies

The case study is an interesting research strategy since it utilises naturally existing information sources such as people and interactions between people within the scope of the case (Hyett et al. 2014). It is a research strategy that helped us to understand the phenomena in real-life situations (Yin 2003). 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 HEIs were chosen in order to obtain a representative sample of the spectrum of higher education in Portugal. In this multiple case study, the rationale and boundaries for the selection were the engagement of HEIs from university and polytechnic education, private and public institutions, as well as larger and smaller HEIs,

because we know how important it is for our sample to be generalised and for our findings to be applicable to any type of HEI. Thus, in this phase of our project, we conducted semi-structured interviews with senior managers from HEIs during the second quarter of 2020 (due to the pandemic situation, the later interviews were online through video conferences). 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. 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. In this study the institutions are therefore referred to as HEI1, HEI2, HEI3, HEI4 and HEI5, and each expert was coded from E1 to E7 (Table 1).

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 project, the study, 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 data collection stage were analysed via content analysis, an objective and systematic form of data analysis applicable to analysing data such as semi-structured interviews (Bell and Bryman 2007). Content analysis is a systematic data analysis technique that collates valid inferences from texts into fewer

Table 1 Generic information for interviewees

HEI code	HEI dimension (no. of students)	HEI type	Expert (code)	Current role	Experience (years)	Background
HEI1	> 15,000	Public	E1	CIO	22	Development
HEI2	> 10,000	Public	E2	Team Leader	22	Management IS
HEI3	> 20,000	Public	E3	CIO	21	Management IS
			E4	CIO	18	Management IS
HEI4	> 4000	Private	E5	CTO	13	Development
HEI5	> 30,000	Public	E6	CIO	16	Management IS
			E7	Team Leader	20	Management IS

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 (Robson 2002), and is reliant on the quality of information contained in the documents or transcripts (Bell and Bryman 2007), it is a transparent, flexible and systematic data analysis technique (Bell and Bryman 2007).

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. In Sect. 4, we discuss the results.

3 Information systems: HEI dimensions

3.1 Model architecture

During the interview process and the further final analysis of each case study, we came to an initial decision regarding the best way of structuring the identified dimensions. Many of them are transversal to the organisation, including cross-cutting activities to all the functional areas of the HEI. In order to make this concept clear, we give the example of data analysis and reporting. These two activities exist in all dimensions with more or less relevance. In the scope of our model, we named these as horizontal dimensions, because they are transversal to the entire organisation. 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

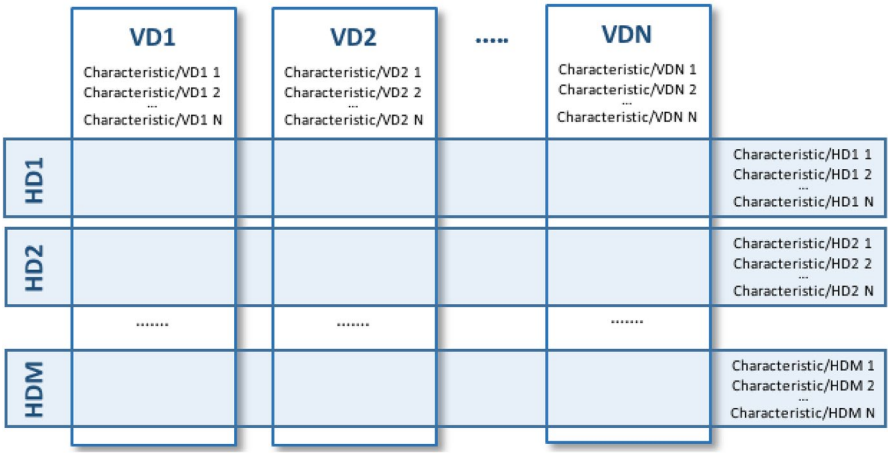

Fig. 1 Architecture of a higher education institutions information systems maturity model

within a strict functional area, at all levels, in a vertical perspective. As examples, we give the academic and financial departments.

In this perspective, it was possible to define a two-dimensional architecture of the HEI maturity model, composed of 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.

3.2 Vertical and horizontal dimensions

Next, we will briefly discuss each of the identified dimensions that we named as vertical:

- *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. Academic management is a very complex activity, because it encompasses a lot of concepts, such as enrolment, course, subjects, degree, academic year, school, student, and many others. From one HEI to another, these concepts may have distinct interpretations, as well as from one school to another within the same HEI. In general, an HEI is organised in schools (e.g. School of Engineering, Humanities, Arts, Social Sciences, and others) and/or Departments, or other types of substructures. The majority of the processes are specified by internal regulations of the department, school or HEI, which follow certain principles (e.g. the Bologna Treaty) and other national regulations. As a consequence, within an HEI, there may exist several regulations for the same process, depending on the department and/or school. Another problem is the volatility of those regulations, which may change from one academic year to the next.

  Many of the processes have connections with other dimensions, in particular the Financial one (discussed next). All these aspects, multiplied by the numerous processes, make the work of IT teams a nightmare, as also for the people that work in these services and who must attend, in many cases, to thousands of students, candidates and, depending on the services' organisation, to the teachers as well. Besides attendance, the HEI's academic services must also provide numer-

ous reports and statistics for the HEI's direction and external governmental services. This dimension was suggested by all the experts interviewed.

- *VD_FM*: *Financial Management* this is another dimension with huge importance in the HEI, as well as in any other type of organisation. This dimension encompasses all issues regarding accounting, treasury, budget control, expenses approvals, and all the other ones related with financial management and control. In the context of our study, the Portuguese HEIs, these are very distinct between the public and non-public cases. By law, public HEIs must follow specific accounting principles, which have some differences from private HEIs. The HEI's financial services must also provide reports and statistics for the HEI's direction and external governmental services. Additionally, it has many strong points of contact with other dimensions such as: academic, human resources and project management. This dimension was suggested by all the experts interviewed.
- *VD_HRM*: *Human Resources Management* in general, all types of organisation have this dimension. However, in the case of HEIs, it has several particularities, which increase the number and the complexity of the organisational processes. The human resources management includes the maintenance of personal data, of teachers, researchers and staff, salaries, career progression, hiring workflows and attendance control. In the case of teachers and researchers, these activities may have a considerable level of complexity and can be time-consuming, due to the limited period of time for hiring that some of them may have. It is very common to hire a teacher only for one academic year or a semester. Typically, this type of hiring follows a formal workflow of approvals at scientific and financial levels. This dimension has a very strong connection with the Financial Management and involves several workflows that cross other dimensions of the HEI. This dimension was suggested by all the experts interviewed.
- *VD_TS*: *Teaching Support* the teaching activities produce and consume data. These may fit into one of three categories: (1) Data relevant to the academic services (the Academic Management dimension), such as the students' final grades; (2) Data relevant to the teaching activities managed by teachers and students; that is, all evidence of students' effort to obtain the ECTS of each unit, such as summaries of classes, students' attendance, course unit sheets (course syllabus) and final unit report; (3) e-learning management—here we exclude the learning process itself. We only consider data that is relevant to the e-learning, such as which students have access to the LMS platform. In short, in this dimension, all data regarding the teaching process is managed. This dimension was proposed by the authors based on their personal experience.
- *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) concept (Schöpfel et al. 2017). The management of research information has different perspectives/needs: (1) The researcher—he/she needs to store data and metadata about his/her personal CV, as well as to make it publicly available; (2) The research units—for their project and fund management, and external evaluation in terms of results, such as products, patents and publications; (3)

The HEI—for managing, measuring and obtaining statistical indicators, of their organisational units, funding, facilities, equipment and events; (4) The research community and enterprises—they have an interest in knowing the current research and its impact, and having tools for networking; and (5) Society—also has interest in knowing about the current research fields and their impact.

These distinct perspectives and needs must be attended to by HEIs as part of their mission. Currently, there are several solutions (Schöpfel et al. 2017) to implement CRIS, as well as the CERIF (Common European Research Information Format) standard (EuroCRIS 2020) for interoperability. Ideally, the research information should be seamlessly integrated with data of other dimensions, such as Financial and Human Resources, in order to get synergies from these areas of the HEI.

- *VD_Com*: *Communication* in general, HEIs have large communities of students, teachers, researchers, and staff. Thus, 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. In order to manage all this information, the HEIs have adopted SRM (Student Relationship Management) and other tools integrated with the application ecosystem to automate this communication.

  External communication also requires the management of information: marketing, approval workflow of institutional marketing, etc.

  The compliance with the new GDPR (General Data Protection Regulation), introduced in May 2018, amplifies the complexity of external and internal communication in HEIs.
- *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* some of the experts (E4, E6 and E7) interviewed consider that student exchange programs, like ERASMUS, also have specific requirements in terms of information management. Here we exclude the issues related with the academic dimension, because, in general, a foreign exchange student follows rules similar to those of ordinary students. On the other hand, the HEIs' own students who are in foreign HEIs require additional procedures with specific issues of information management. In this dimension we also include all issues related with the management of attracting new international students, besides the ones in exchange programs. We should note that the international research partnerships are in the scope of research dimension (VD_RM).
- *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. Here, we exclude research projects since they are already managed in the research dimension (VD_RM), and due to their particularities. This dimension was suggested

by two of the experts (E4 and E7) who were interviewed. We were here inspired by the literature (Demir and Kocabaş 2010) in proposing this dimension.

- *VD_BM*: *Building Management* this is another dimension suggested by the experts. In general, HEIs have several campus sites dispersed geographically. This dimension considers the management of all the information about buildings, laboratories and equipment. This dimension was suggested by three of the experts (E3, E5 and E6) interviewed.
- *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. This dimension was suggested by two of the experts (E3 and E5) interviewed.

As previously mentioned, the horizontal dimensions relate with 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* many of the HEIs' processes are transversal to the organisation. In the studied HEIs, we observed two ways of dealing with this type of process: (1) implemented in the business logic layer of the applications; or (2) using workflow and/or document management engines or a bus of services. This dimension focuses on both scenarios, 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). Here we intend that the model should evaluate all characteristics regarding the interoperability across the modules associated with the dimensions participating in the cross-cutting processes.
- *HD_INT*: *Interoperability* the interoperability with external systems is another challenge to HEIs. Nowadays, student exchange programmes, as well as shared courses, require data interchange among two or more HEIs. Additionally, there is an intensive data interchange with governmental services in order to provide statistical data about students, teachers, courses, etc. These problems are complex due to distinct HEIs' data models, especially in the former case, since in the latter a common data model is imposed by the central gov-

ernmental service. Thus, 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. Thus, all the experts who were interviewed agreed to include this dimension. We were here inspired by the literature (Carvalho et al. 2018a, 2019) in proposing this dimension.
- *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 (Solar et al. 2013) 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 (Kenny 2006; Solar et al. 2013).

4 Discussion of the results

As previously mentioned, a two-dimensional architecture is proposed for our maturity model. Our 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 regarding each vertical dimension. Thus, it will enable the coherence of the evaluation of the vertical dimensions regarding the horizontal dimensions, which define a set of characteristics shared by all of them, because the same characteristics are always considered. Consequently, 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, users can obtain specific or global maturity levels in terms of the horizontal dimensions. For example, one can get a comprehensive vertical view of the maturity level of the Academic Management (a vertical dimension) considering the aspects of Reporting Tools capabilities (HD_RT), as well as all the other cross-cutting characteristics (horizontal dimensions). Or, can get a comprehensive horizontal view of the maturity level of the Reporting Tools capabilities regarding the entire IS, or alternatively can get very

specific information about the maturity level of Reporting Tools restricted to the scope of the Academic Management. We should note that the maturity level regarding a cross-cutting characteristic of a horizontal dimension may be distinct in the scope of each vertical dimension. That is, one cross-cutting characteristic may have a different influence on the maturity level from one vertical dimension to another.

Based on the literature (Carvalho et al. 2018a, 2019) and the authors' expertise in the design and management of ISs of HEIs, an initial set of dimensions was identified. This set was the starting point of the interviews. Our approach for conducting the interviews was based on the following steps: (1) ask for data about the personal experience of the interviewed experts; (2) explain the main concepts, with special care in the case of what is a dimension, presenting the VD_AM and HD_RT as examples; (3) ask for dimensions according to the expert's experience; (4) present and discuss others that we have previously identified; and, finally, (5) ask (again) if they have other dimensions to propose for our model.

The majority of those dimensions previously identified were consensual among the experts. Some of them, such as VD_FM and VD_HRM, were immediately mentioned by them without giving any clue or suggestion. Other dimensions, such as VD_RM, VD_Com, VD_Alumni, HD_DA and HD_SEC, were accepted immediately after being proposed by the authors. In a third group (HD_WF, HD_INT and HD_UU) some clarification was needed, but they were accepted by the experts without posing objections.

Three dimensions that were proposed in the initial set took a lot of discussion. For all the interviewees, these three, VD_TS, HD_US and HD_TI, were not obvious when we presented them for discussion. Regarding the VD_TS, some experts (E2, E3 and E6) considered it as part of the VD_AM. Indeed, this dimension has many features that relate to academic management issues, being in the frontier of the teacher's tasks and issues of the academic services. As an example, we present the case of the recording of the students' grades into the platform, a task usually performed by the teachers in all the HEIs considered in this study. From the point of view of the academic services, the students' grades are data that result from the teaching activities, in which the teachers and students are the producers of the data. Thus, the proposed dimension VD_TS encompasses all issues of teaching activities, as previously discussed in Sect. 3, reducing the complexity of the VD_AM regarding the processes that involve the teacher/student and teacher/teacher relationships. The VD_TS produces and consumes data from VD_AM, as well as from other dimensions.

The HD_US and HD_TI also generated a lot of discussion because they do not relate directly to the problem of the management of the HEI's information. Our discussion with the experts was focused on the motivation for evaluating these two dimensions in order to measure the maturity level of the IS so as to accomplish its mission. The conclusion is that these two dimensions have an impact on the effective functioning of the platform and people's interaction with the platforms, and consequently have a considerable impact on the general performance of the management of the information.

Based on the literature (Kenny 2006; Solar et al. 2013), the persons and their strategy influence the maturity levels, and these are especially important characteristics

if is intended to find higher levels of maturity. This dimension was presented and discussed with the experts, and was accepted by all.

The experts E4, E6 and E7 proposed the dimension VD_IR for specific issues about exchange and international relations. In general, exchange programs are dealt with by specialised teams either separated from the academic services or integrated into them. Despite the particularities of the issues of exchange students, many aspects are common to academic services. Thus, the VD_IR relates to all aspects that are specific to international relations in the scope of exchange and other programs. This approach enables the evaluation of those particularities including those that are common to VD_AM.

During the discussion of the dimension VD_RM, two experts (E4 and E7) proposed the dimension VD_PM for issues related to project management. Research projects and non-research projects have common aspects in terms of management. This dimension intends to evaluate how the information is managed, only in the perspective of project management, irrespective of the type of the projects, including the scientific aspects for the VD_RM and research methodologies.

The experts E3, E5 and E6 proposed the dimension VD_BM, because usually HEIs have one or more campus with buildings and infrastructure. Irrespective of the type of HEI, public or private, these are relevant issues to manage.

5 Conclusion and further work

Maturity models that can support 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 IST maturity models and it is particularly scarce on maturity models focused on the comprehensive management of complex HEI information systems.

The present paper reports the current state of the development of an encompassing maturity model for HEI information systems. This maturity model is being developed to address the complexity of the HEIs and offer a useful tool for the demanding role of management of the ISs. Additionally, this model is being developed respecting the procedures of a specific methodology for the development of maturity models (Mettler's methodology 2010), with a view to guaranteeing its recognition, solidity and relevance, both in the academic community and in society in general. Our work is now at that third step of Mettler's methodology, the design stage of the maturity model. At this stage of development, we are adopting a multicase study to interview a diverse group of seven IS managers from Portuguese HEIs.

In this paper, we present and discuss our approach based on a two-dimensional architecture composed of vertical and horizontal dimensions to be applied in the model that we intend to develop. The results of this research work have been both encouraging and promising amongst the interviewed experts, revealing a high level of acceptance of the general model architecture as well as positive expectations about its usefulness in the future. The set of dimensions that were identified answer the research question RQ, formulated in Sect. 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 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 from different countries. The results of this survey will be analysed, producing the necessary inputs for the design of the first version of the model. Subsequently, this first version of the model will be validated following the Mettler methodology for developing maturity models.

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