Modelos de Maturidade em um Cenário Educacional:
Um Mapeamento Sistemático

Raul Donaire Gonçalves Oliveira, ICMC-USP, raul.donaire.go@gmail.com

Ellen Francine Barbosa, ICMC-USP, francine@icmc.usp.br

Resumo. *Este paper apresenta um mapeamento sistemático em modelos de maturidade educacionais, almejando identificar e reunir as suas principais características, inspirações e métodos de desenvolvimento. Foram identificados 22 modelos de maturidade educacionais, divididos em 25 estudos. Os resultados apontam que CMM, CMMI e SPICE são as inspirações mais comuns para os modelos educacionais existentes. Também foi constatado que estudos literários, pilot testing, workshops e surveys foram os métodos mais comuns utilizados para desenvolver tais modelos. Finalmente, não foi possível encontrar nenhum estudo especificamente relacionado a modelos de maturidade para recursos educacionais abertos, destacando uma lacuna na área que pode ser apurada em trabalhos futuros.*

Palavras-Chave: *Modelo de Maturidade Educacional, Mapeamento Sistemático, Recurso Educacional Aberto.*

Maturity Models in the Educational Setting:
a Systematic Mapping Study

Abstract. *This paper presents a systematic mapping study on educational maturity models, trying to identify and gather their main characteristics, inspirations and design methods. We identified 22 educational maturity models, divided among 25 studies. The overall results pointed out that CMM, CMMI and Spice were the most commons inspirations for the existing models nowadays. We also noticed that literature studies, pilot testing, workshops and surveys were the most common design methods for such models. Finally, we could not find any study specifically related to maturity models for open educational resources, highlighting a research gap to be bridged in future works.*

Keywords: *Educational Maturity Models, Systematic Mapping Study, Open Educational Resources.*

1. Introduction

Education has evolving increasingly faster in recent years. Computers, mobile devices and the growing access to the Internet have playing a big role in these changes. They provide freedom and autonomy to the modern student, who can choose when, where and how to learn and consume each one of its interests. Schools, colleges, universities and online courses are in need to adapt and reinvent themselves in order to keep up with this new trending (Jamieson and Herdtner 2015)(King and Boyatt 2015).

The academic community is also aware of this transformation, investigating several different research topics in this area, like the effects tof mobile learning in motivation and well being (Jeno *et al.* 2019), how to evaluate the student satisfaction in e-learning applications (Violante and Vezzetti 2015) or how to assess the overall quality of Massive Open Online Courses (MOOCs) (Foley *et al.*, 2019).

Despite the existence of several initiatives around the world related to the improvement of education, there is still some concerns and issues about its expansion and sustainability. Some authors argue that there is a large gap between the best and the worst educational institutes (Ramanamurthy *et al.*, 2012), and some modern learning modalities, like mobile learning, still presents significant barriers and difficulties that hinder its effective implementation (Huang *et al.*, 2010).

In a different but related perspective, Capability Maturity Models (CMM) (Paulk *et al.,* 1993)(Paulk, 2002), originally adopted in software process improvement, have emerged as an interesting alternative for process improvement in the educational area (Mughrabi, Jaeger, 2018). In short, a Capability Maturity Model is a development model that measures the ability of an organization for continuous improvement in the software development context. The higher the level of the organization, the higher is the chance of improving through their mistakes. Each level contains a series of activities and processes that are necessary to accomplish a given standard of maturity, which is related to the quality assurance of the resulting products. Once the organization is assigned to a level, it should be clear which new steps must be taken to reach a higher status.

Motivated by this scenario, in this paper we describe the planning and conduction of a systematic mapping study in order to provide an overview of the state-of-the-art of maturity models being used in the educational setting. The study follows an evidence-based approach, through a systematic mapping. We chose systematic mapping as the research approach since we are interested in getting an overview of the research area (a map), identifying the number and type of researches undertaken and the results available in this area (Petersen *et al.,* 2015).

The remainder of this paper is organized as follows. In Section 2 we discuss the planning of the systematic mapping study conducted. In Section 3 we analyze the data and results obtained from the systematic mapping study. In Section 4 we summarize the main findings and concluding remarks.

2. Systematic Mapping Study

Unlike traditional literature reviews, usually carried out in an ad-hoc way, a systematic mapping is formally planned, having well-defined stages to minimize bias and produce research with scientific significance. In order to conduct this mapping study, we followed the process proposed by Kitchenham and Petersen (Kitchenham, Charters, 2007)(Petersen *et al.,* 2015).

The main objective of this study is to characterize the maturity models proposed and used to support the quality of educational processes in general. We are interested in their main aspects, their inspirations and which methods or strategies were used to design them. There was also a concern of how many of the retrieved maturity models are particularly related to OERs. To address the main objectives of the study we defined three Research Questions (RQ):

RQ1. What maturity models have been proposed and used in educational processes?

RQ2. What maturity models from other areas have inspired these educational maturity models?

RQ3. What methods or strategies were used in designing of these educational maturity models?

RQ4. Which of these models are specifically related to open educational resources?

Next, we present a general search string created from the combination of the relevant terms and synonyms defined for the study using Boolean operators (and/or):

*(("education" **OR** "teaching" **OR** "learning" **OR** "student") **AND** ("cmm" **OR** "maturity model"))*

All searches were limited per year, ranging from January 2001 until December 2018. The restriction from 2000 was due to the fact that educational maturity models started appearing in such period. In certain data sources, such as Scopus and Web of Knowledge, searches were also limited by area, i.e., Computer Science, Engineering, Education and Educational Research. To obtain coherent and consistent results for the research, we defined some inclusion and exclusion criteria for the retrieved studies.

Inclusion Criteria (IC) included:

IC1. Studies describing the application of maturity models in educational processes

IC2. Studies focusing in the design of maturity models in educational processes.

Exclusion Criteria (EC) included:

EC1. Studies not focusing on educational maturity models.

EC2. Studies describing maturity models applied in other area.

EC3. Studies not fully available for download and reading.

EC4. Studies not published in English.

A total of 2057 studies were retrieved. In Table 1 we summarize the number of studies selected in each data source, both in the first and in the final selection phases. In the first selection, we identified 77 potentially relevant studies. After a complete reading of the studies, we identified 25 primary studies relevant to the research objectives.

Table 1 - Summary of the included and excluded primary studies of each data source.

Data Sources	Results	First Selection		Final Selection	
		Included	Excluded	Included	Excluded
Scopus	697	39	658	14	25
Compendex	602	13	589	5	8
IEEE Xplore Digital Library	386	5	381	1	4
Web of Knowledge (Web of Science)	308	19	289	4	15
ACM Digital Library	64	1	63	1	0
Total	2057	77	1980	25	52

3. Data Analysis and Results

In Figure 1, we show the distribution of the primary studies according to the year of publication, from 2002 to 2018, synthesizing the community's interest in this research area through the years. As can be observed, the first studies on the area appeared on 2002 and 2004, lead by the papers from (Duggins, 2002), (Petrie, 2004), (Marshall; Mitchell, 2004) and (Neuhauser, 2004). After a lack of studies between 2005 and 2008, the community rekindled their efforts from 2009, with a peak of four studies in 2013.
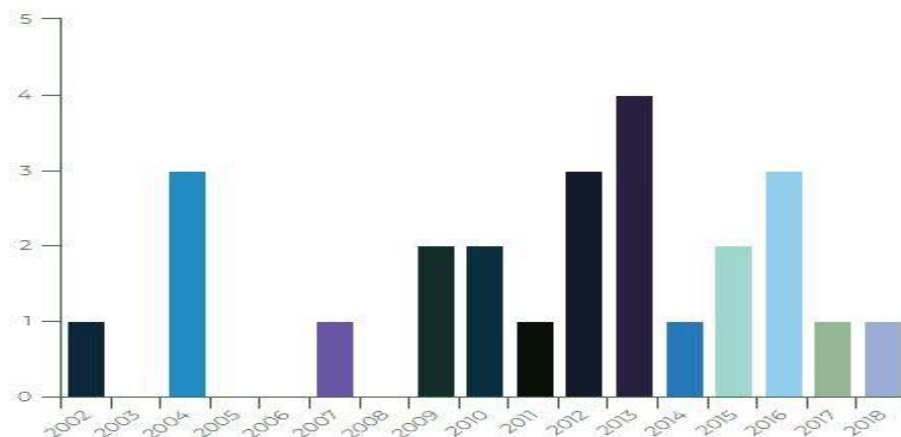
Figure 1 - Distribution of the primary studies by year of publication.

In Figure 2, we present the distribution of primary studies per country. As can be observed, United States and New Zealand shows appears with three studies each. It is also interesting that every continent was represented by at least one study, which shows that this topic has some worldwide representativeness.
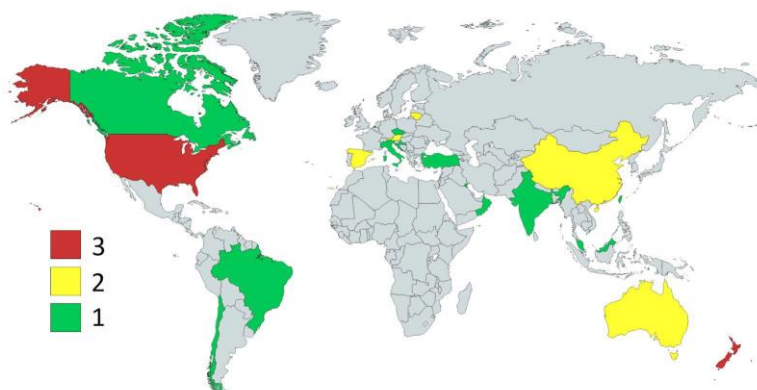

Figure 2 - Distribution of the primary studies by country.

Next we map and summarize our main findings in order to answer the research questions of this systematic mapping.

RQ1. What maturity models have been proposed and used in educational processes?

Table 2 presents the retrieved models, their respective acronyms and references.

The e-learning Maturity Model (eMM) is the one with most appearances in accepted studies, and hence, with the most citations. It was developed by a collaboration from S. Marshall and G. Mitchell, merging the concepts of CMM (Paulk *et al.*, 1993) and SPICE (Dorling, 1993), in order to provide a robust system for improving development process in online delivery of teaching. In its first version, the model had more than 40 processes, divided in five categories (learning, development, coordination, evaluation and organization). Each process was evaluated through 6 capability levels

(not performed, initial, planned, defined, managed and optimising). The maturity level of the organization was defined based on the results of this assessment. The model also evolved through the years, being used in several applications, including an analysis of Australian institutions and a series of workshop evaluations.

Table 2 -Educational Maturity Models Retrieved

Studies	Acronym	Name	Reference
S01	ICTE-MM	ICT in school Education - Maturity Model	(SOLAR et al., 2013)
S02	CEMM	Computing Education Maturity Model	(LUTTEROTH et al., 2007)
S03	OCDMM	Online Course Design Maturity Model	(NEUHAUSER, 2004)
S04	—	The Delta Maturity Model	(Guitart et al., 2016)
S05, S07, S11, S24	eMM	e-learning Maturity Model	(Zhou; Zhang, 2008), (MARSHALL; MITCHELL, 2004), (MARSHALL, 2009), (MARSHALL, 2013)
S06	—	m-Learning Maturity Model	(Alrasheedi; Capretz, 2013)
S08	CDMM	Curriculum Design Maturity Model	(THONG et al., 2012)
S09	TDWIMM	The Data Warehouse Institute Maturity Model (adapted)	(RASHDI; NAIR, 2017)
S10	—	CMMI for educational institutions	(Ramanamurthy et al., 2012)
S12	—	Maturity Model for supporting higher education graduates' early careers	(ANIČIĆ; DIVJAK, 2015)
S13	EduSpice	SPICE based education capability maturity model	(MITASIUNAS; NOVICKIS, 2011)
S14	ICMM	Intellectual Capital Maturity Model	(SECUNDO et al., 2015)
S15	TeaM	Teaching Maturity Model	(REÇI; BOLLIN, 2017)
S16	ACMM	Academic Management Maturity Model	(SILVA; CABRAL, 2010)
S17	OCQMM	Online course quality maturity model	(GU et al., 2011)
S18	—	Maturity Process Teaching Model	(DUGGINS, 2002)
S19	PMMM	Project Management Maturity Model	(DEMIR; KOCABAŞ, 2010)
S20	T-CMM	Teaching Capability Maturity Model	(CHEN et al., 2014)
S21	—	Engineering Education Capability Maturity Model	(PETRIE, 2004)
S22	UNEK	Academic Entrepreneurship Maturity Model for Technological Faculties	(MARKUERKIAGA, 2017)
S23	SESR-MM	Student Engagement, Success and Retention - Maturity Model	(NELSON et al., 2015)
S25	PBLCMM	Project Based Learning Capability Maturity Model	(MUGHRABI; JAEGER, 2018)

EduSpice, presented by (Mitasiunas, Novickis, 2011), is an example of a SPICE-based model. The authors goal was to develop a ISO/IEC 15504 conformant education process capability maturity model, introducing a participative approach to education capability assessment and improvement. It has 10 primary processes (*Reflective Research, Course Development, Production, Distribution, Course Delivery, Academic Student Support, Assessment, Education Support System, Registration, and Learning*), each one of them being composed by several sub-processes, its own goals and purposes. However, the model validation was not included in the study.

Finally, as an example of CMMI-based model, the study performed by (Mughrabi, Jaeger, 2018) the Project Based Learning Capability Maturity Model (PBLCMM). The model is presented in three KPAs: *quality of PBL project, quality of PBL facilitation and quality of PBL assessment*. They designed its activities by

interviewing area experts and validated by applying them in two case studies. They concluded that the model could be improved by introducing adequate control of authenticity of students' work, as well as considering students' effort throughout the span of the project, and, in order to institutionalise the PBL model, it will be necessary an introduction of general goals and practices.

RQ2. What maturity models and standards from other areas have inspired the retrieved educational maturity models?

We present the results of this question in Figure 3. As can be seen, CMM (Paulk *et al.*, 1993)(Paulk, 2002) presents the most influence with 53.3% of appearance in accepted papers, followed equally represented by SPICE (Dorling, 1993) and CMMI (Team, 2006), both with 20%. At last, TDWIMM (The Data Warehouse Institute Maturity Model) and OCDMM (Online Course Design Maturity Model), both with 3.3% of the total amount.
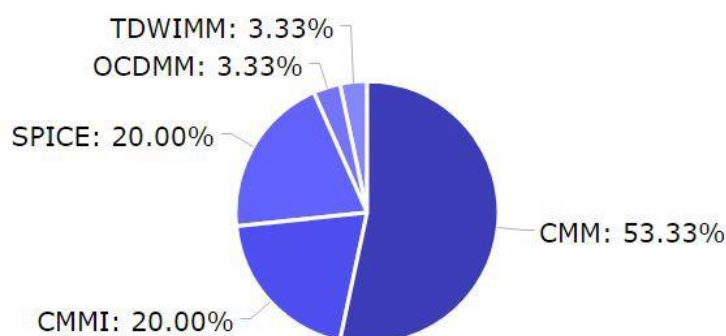

Figure 3- Maturity Models used as inspirations by the primary studies.

In *b i t . l y / 3 3 1 m H t 0* there is a representation of these results as well, but also demonstrating which model/standard inspired each one of the retrieved educational maturity models. Some models had more than one inspiration (eMM, m-learning MM). CDMM was the only model that was directly based on another educational maturity model. From the SMS performed, we observed that the retrieved models characteristics were mostly inherited from their predecessors, specially CMM and CMMI.

RQ3. What methods or strategies were used in designing of these educational maturity models?

This research question aims to discover what methods or strategies the authors from accepted studies used to design their educational maturity models (Figure 4). Unfortunately, there is a high number of studies that failed to answer this question: a total of 10 studies did not provide sufficient information in this topic. Following that, 6 studies designed their models only studying older models. With the third most appearance, with 4 studies, there were ones that also based their models in previous studies, but additionally performed a test using pilot versions, improving it after feedback. Aiming at a higher and more qualified volume of criticism, there were studies that designed their models using suggestions from experts through workshops and

surveys, with 2 appearances each. At last, there was a study using Mettler MM Design Method (Mettler, 2010).
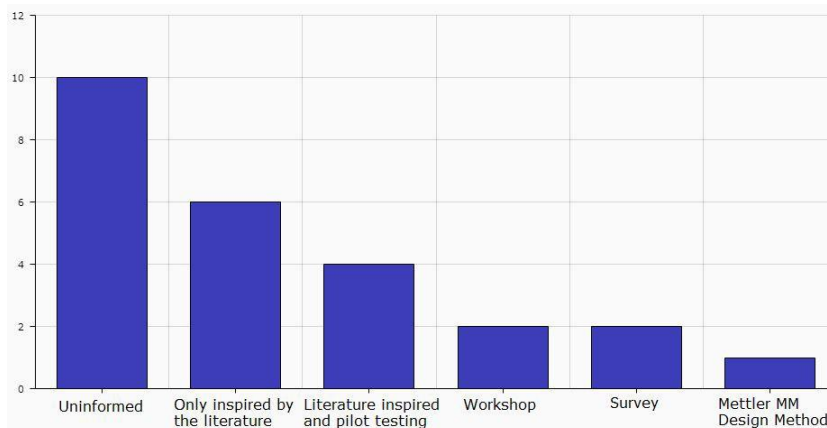

Figure 4 - Design methods retrieved from accepted papers.

Finally, in Figure 5, we mapped how each retrieved model was designed (axis x) with their inspirations (axis y). The combination of CMM inspiration and unspecified designed methods had the most appearances (9). The second and third combinations with the most hits were CMM/Literature inspired (4) and SPICE/Unknown (3), respectively. CMMI was the only inspiration that was paired with Surveys and the Mettler Design Method.
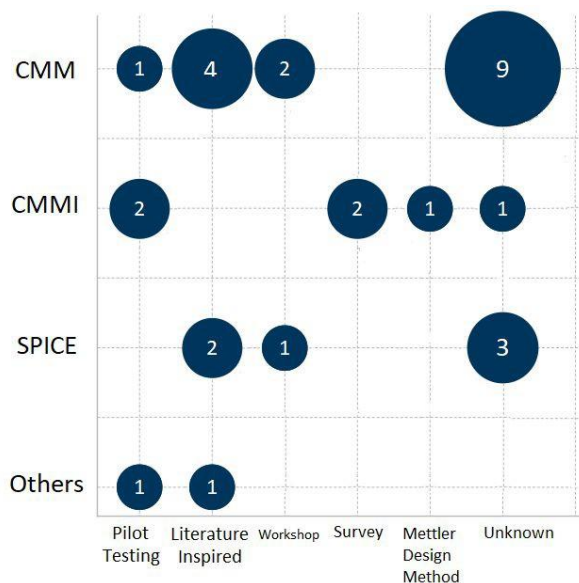

Figure 5 - Relation between how each study was designed and what was its inspiration.

RQ4. Which of these models are specifically related to open educational resources?

As was said in a previous section, every approved paper was subjected to a thorough reading in order to answer all four of the research questions. And none was related to, or even mentioned, open educational resources. There was also said that, OERs have potential to enhance the education at a global level, jump starting careers and economic development in communities that lag behind, helping to reduce socioeconomic inequality (Hewlet, Hewlet, 2002). It is a major educational topic of this decade, a quick

search at Scopus database shows more than 1200 studies retrieved using the keyword "open educational resources".

The lack of presence of this topic among the retrieved studies highlights a gap in the area, demonstrated by the concern that some authors posses over the overall quality of future educational resources (Hylen, 2006)(Arimoto, Barbosa, 2013).

4. Conclusions and Future Work

In this paper we described a systematic mapping conducted in order to provide an overview of the state-of-the-art of maturity models being used in the educational setting. From this mapping, We were able to identify 22 educational maturity models, divided among 25 studies.

In short, we identified their inspirations, previous models and standards that influenced their design -- CMM, CMMI and Spice were the most common ones. We also investigated which methods the authors were using to design their models. Unfortunately, a high number of studies failed to answer this question, but literature study, pilot testing, workshop and surveys were common answers as well. Finally, we noticed that no study was related to open educational resources, highlighting an important research issue to be addressed in future investigations. The summary of how each approved study answered every research question can be found at https://imgur.com/a/WZzvDnz.

The results can help to understand the main needs regarding the design and evaluation of educational maturity models, by identifying issues that still require investigation, or particular needs on the development process that have not been addressed yet. The systematic mapping can also serve as a guide to help researchers and practitioners in planning and developing future research. We hope this research contributes to deepening the discussions and enhancements of the educational maturity models, specially in the OERs context.

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