A Conceptual Modelling Study for a Learning Management System in Doctoral Schools

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Abstract: This research promotes the implementation of a specialised Learning Management System (LMS) for doctoral schools by identifying the required information, features, qualities, and actors and their specific roles. An extended literature assessment informs the structuring of information regarding the expected returned benefits; while the related findings are analysed using the graph and concept algebra. Five major components are identified as having a significant impact on the doctoral programme. One of them, namely *social behaviour*, poses a lack of connectivity with the rest of the identified components. The present research also looks at the expected impact created by the community of *social behaviour* as induced by the implementation of a specialised LMS for doctoral school. *Cooperation, collaboration* and *professional socialisation* enhance the overall effect of process improvement. *Compliance and conformity* is the main engine involved in strengthening the connectivity between LMS and *Cross-disciplinarity*. To study the proposed LMS structure, a conceptual design framework, along with a possible configuration, supply the proper description of how the LMS can be present within the doctoral school.

Keywords: science advance, doctoral programme, research management, community integration, knowledge representation

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Introduction

Assessing the requirements of the Romanian Agency for Quality Assurance in Higher Education, one can note that the focus on scientific research is the primary objective of any doctoral programme (ARACIS, 2006). The institution has a long-term strategy and medium and short-term programmes which address the research objective, projects and expected outcomes, as well as the resources required. There is a research ethos and culture, and mechanisms for validating the research outcomes. (ARACIS, 2006: 30).

The specific implementation remains at the decision of the university and doctoral school (ARACIS, 2006). The long-term strategy and medium and short-term research programmes are adopted by the university Senate and the Councils of faculties, which also specify the practices for obtaining and allocating resources and the means for validating the research outcomes. The research interests are predominantly institutional. (ARACIS, 2006: 30).

The objective of this paper is to propose a possible configuration for a specialised Learning Management System (LMS) in doctoral schools which would increase the effectiveness of compliance with the Agency's requirements and the conformity of the scientific research outcomes.

Theoretical Background

We carried out a literature assessment in order to capture the significant aspects of a doctoral school, covering the interval between 2006 and 2018. The literature reveals the following meaningful domains: (i) education, (ii) science advance and (iii) community integration.

Keywords and Titles Selection

With the three domains of interests introduced by ARACIS (2006), i.e., education, science advance and community integration, a list of as-extracted keywords has been adopted.

Table 1 Keyword set used for title selection	
Keyword	Keyword
Educational grant	Advancing knowledge
Scientific dishonesty	Intellectual discovery
Student trust	Advanced research methods
Career development	Cross-disciplinarity
Research article	Core scientist
Independent study & practicum	Scientific consultant
On-site course	Professional practice expert
Online course	Strategic case actor
Science diversity	Local case actor
LMS	Social behaviour
External evaluator	Professional socialisation
Collaboration	Compliance and conformity
Cooperation	Liminality
Mentoring	
Counselling	
Peer-networking	
Bridge-tie concept	
Legend: the community identification is underlined.	

For exemplification, the domain of science advance generates in the first line the keywords of *advancing knowledge*, *intellectual discovery*, a*dvanced research method* and *cross-disciplinarity*. With the resulting keywords, a set of titles connecting the selected keywords is retained. Overall, a list of 41 keywords is created. Those specific keywords not developing any relation type (see The Knowledge Base for details) were removed from the list, such that, finally, 27 of them were considered (*Table 1*). Based on the selected keywords, the titles which (i) supply the keyword definition, or (ii) introduce (binary) relation to other keywords, were chosen for the literature assessment resulting in a reference list with twenty-one entries to construct the knowledge base.

The Knowledge Base

The selected method for knowledge representation (Keet, 2008; Wang, 2017) follows a general structure of nodes and edges (*Figure 1*) and relies here on the relation expressed by Equation (1):

$$G(Kn) = \{Kw(In), R, Kw(Out)\} \quad (1)$$

The entity of Relation, covers domains of mereology, meronymy, causality, participation and quality association.

The modularity of G(Kn) shows certain classes (communities) (Fortunato, 2010) as further detailed below.

Educational Grant

The *Educational grant* represents an important sector for the domain of any doctoral school (Kim et al., 2009; Muhar et al., 2013; ARACIS, 2006; EHEA, 2017). Doctoral programmes focus on the advancement of knowledge through original research (Muhar et al., 2013; EHEA, 2017). The doctoral programme strives to solve complex sustainability problems in both academic and non-academic settings (Muhar et al., 2013).

Specific components define the *Educational grant*: *career development* (Kim et al., 2009; Heflinger & Doykos, 2016), *independent research* and *practicum* (Kim et al., 2009; Hellweg et al., 2011), *research articles* (Kim et al., 2009; Prasad, 2015) and *student trust* (Muhar et al., 2013; Hellweg et al., 2011; Prasad, 2015). It means that *career development* comes mainly though *research*, while *independent study* and *practicum* are the main engines in attaining the goal. However, the entities of *student trust* and *career development* get causality from *scientific dishonesty* (Heflinger & Doykos, 2016; Hellweg et al., 2011; Hofmann et al., 2013). The *educational grant* also gets causality from the entities of the *on-site course* and *online course* (Kim et al., 2009).

Science Diversity

Science diversity (Kim et al., 2009; Muhar et al., 2013) enjoys particular importance in the scope of this research work. It is a bipolar community, with both entities of *science diversity* and (*Learning*) *Management System* showing only in-degree centrality. It is interesting to observe that this community has no direct causality with the rest of communities, but through the entities of the *external evaluator* (Kim et al., 2009; Muhar et al., 2013), *cooperation* (Hellweg et al., 2011) and *collaboration* (Enengel et al., 2012).

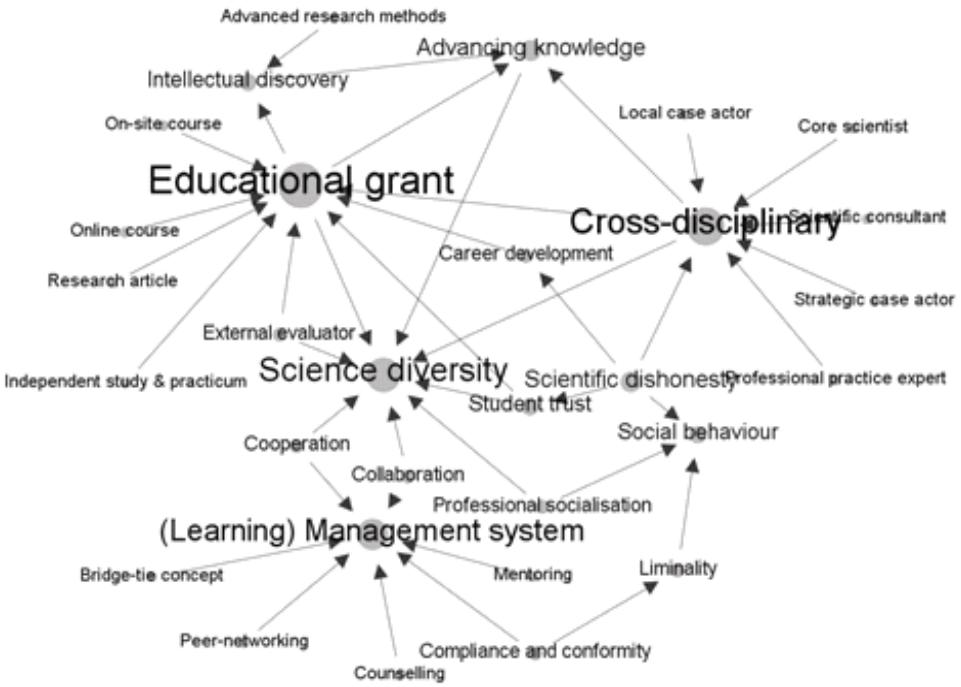

Figure 1 The Knowledge Base

Complementarity is the central principle to engage the inter- and trans-disciplinary research (Muhar et al., 2013; Enengel et al., 2012), but today the main character of a PhD programme shows a lack of being connected with other programmes (Muhar et al., 2013; Nyhagen & Baschung, 2013). The main directions of action enlist the following: a strive for a shared understanding of the critical principles, an increase in knowledge and socio-cultural background heterogeneity, stimulating

the research work to use a robust collective manner (Muhar et al., 2013; Nyhagen & Baschung, 2013; Iliescu et al., 2018).

The entity of *(Learning) Management System* (Kim et al., 2009) is closely connected to *science diversity*. It controls those processes resulting in *science diversity*. The main engine involved in this is the concept of being *collaborative* (Enengel et al., 2012; Iliescu et al., 2018; Iliescu, 2017).

The entity of the *(Learning) Management System* should be self-explanatory. Mainly, it reflects the role of a management system in the function of a university and its affiliated doctoral school(s). However, since several perspectives are potentially equally adopted (see ISO/FDIS 19349) regarding these organisations within the *Management System*, the specialisation of *Learning* was added into the keyword title. Therefore, within this research, the management system is approached with a focus on learning dimension only.

Cross-disciplinarity and Social Behaviour

Cross-disciplinarity (Muhar et al., 2103; Hellweg et al., 2011; Enengel et al., 2012) connects the research activity with the doctoral programme. The term of *complexity* is decoded here as the *complexity of interactions* (Hellweg et al., 2011).

Actors and their interactions become an integral part of the doctoral programme (Enengel et al., 2012). The declared objective of *cross-disciplinarity* is to induce an innovative and creative environment to foster the opening of new scientific perspectives (Muhar et al., 2013).

The *social behaviour* community has a level of importance that comes from the literature as a general topic for education (Kim et al., 2009). Considering the communities of *educational grant* and *cross-disciplinarity*, no direct connection with *social behaviour* exists.

Notable connections are those with *scientific dishonesty* (Hofmann et al., 2013; Bageac et al., 2011; Baxter & Jack, 2008) and *professional socialisation* (Kim et al., 2009; Muhar et al., 2013; Prasad, 2015). Also, *liminality* creates a significant impact on the psychological and sociological scale.

Research Methodology

As introduced in the *Theoretical Background* section, similar projects were investigated and based on the extracted information, the *Knowledge Base* being, therefore, formed. The domains of interests in these projects are described in *Table 1*. It is to be noted that these projects represent individual developments ending in a lack of connectivity (see *Science Diversity*).

This research studies the effect created by the implementation of a specialised LMS, creating an integrated framework for the target doctoral programme. The corresponding simulation environment is presented in *Figure 2*.

Research Question 1: The community of *social behaviour* does not provide bridge-ties with the rest of the communities under study. Can a specific LMS implementation induce/promote such a tie for *social behaviour*?

Research Question 2: What is a possible configuration for LMS that would foster the communication bridge between communities defined for the doctoral programme in respect to network theory?

The knowledge base is constructed and analysed by using graph theory. In this direction, Gephi 0.9.2 software is used in order to generate the characteristics of the graph, as well as in obtaining the graphical representation for the knowledge base and simulation environment. Considering their relevance for this study, the following graph characteristics come under consideration (i) degree, (ii) betweenness, (iii) authority and (iv) hub. Specific graph characteristics' flavour as in-degree, out-degree, among others, were also of interest.

Enhancing the Connectivity

The community of *social behaviour* seems unconnected with the communities reported by the graph analytics and network theory. However, *social behaviour* seems to be on the same level of importance (based on degree centrality criteria) with the entities of *intellectual discovery* and *student trust*.

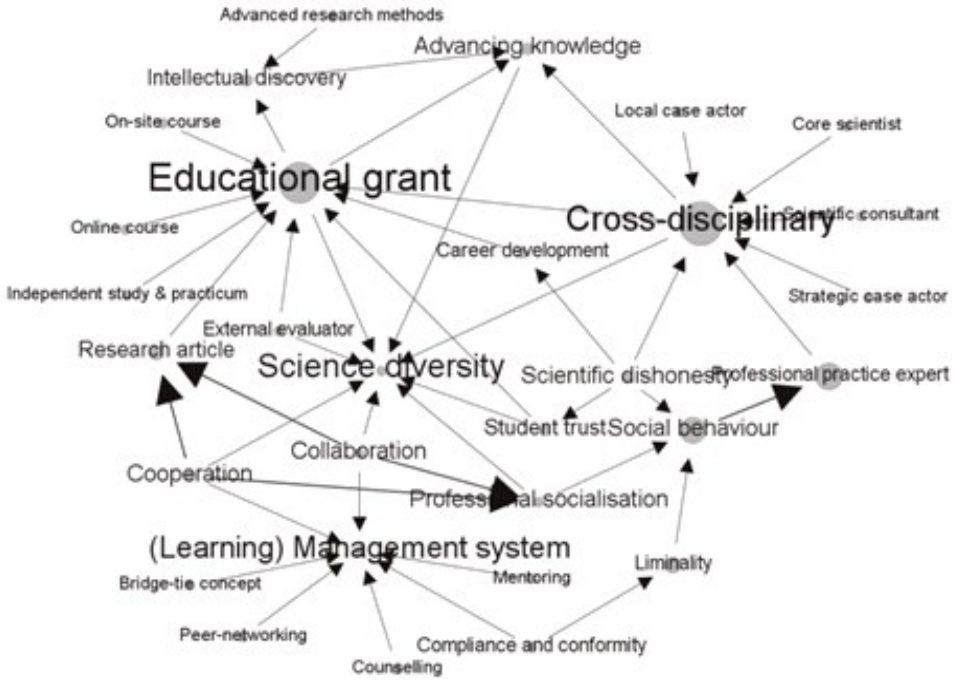

Figure 2 Simulation environment

The results based on *betweenness* show that *social behaviour* has no impact on the domain due to the lack of bridge-ties with the rest of the communities. Results of *authority* and *hub criteria* (graph theory concepts) reveal an interesting fact. *Authority* of this entity is present; there is an outcome of information load on this entity coming from *scientific dishonesty*, *professional socialisation* and *liminality*. However, the hub is null, indicating a possible blockage of information regarding the entity of *social behaviour*.

Collaboration and *cooperation* are the primary engines considered for simulation environment in the *research article* and *professional socialisation*. The *per se* hypothesis is raised here regarding *social behaviour* and *professional practice expert* – the *expert* term exists in a social context. Therefore, *professional practice expert* poses specific *social behaviour* as a feature (*Figure 2*). The declared goal of this relation is to simulate a chain bridge from *social behaviour* to *cross-disciplinarity* and tests the expected effect. One can observe that the communities across the graph form a new structure. Indeed, *social behaviour* is now connected with *cross-disciplinarity* by both *scientific*

dishonesty and *professional practice expert*. Therefore, *professional practice expert* comes in contra-balance with the *scientific dishonesty*, as all these entities are now part of the same community. By consequence, it is the role of the LMS to foster the contribution of the *professional practice expert* within the doctoral programme and the simulation environment in *Figure 2* expresses this concept.

Conceptual Modelling – The Learning Management System

The *complexity* of the problem described results from the literature assessment, accounting not only for the expected level given by the management processes but with the embedded social dimension as well.

The *research centre* is a generalisation for *professional socialisation*, *education*, *library* and *researcher*, and it represents an implementation of LMS (*Figure 3*).

The research herein is motivated by the effect created by the lack of connectivity of *social behaviour*. In this light, the granted users within the LMS (named here *research centre*) require a particular control, including for *professional socialisation, cross-disciplinarity* and *cyber-security*.

There is a specific granularity to record in connection to *research groups*. Considering the *research team* as being the underlying structure in research activity, one or more *research teams* are part of one or more *research groups*.

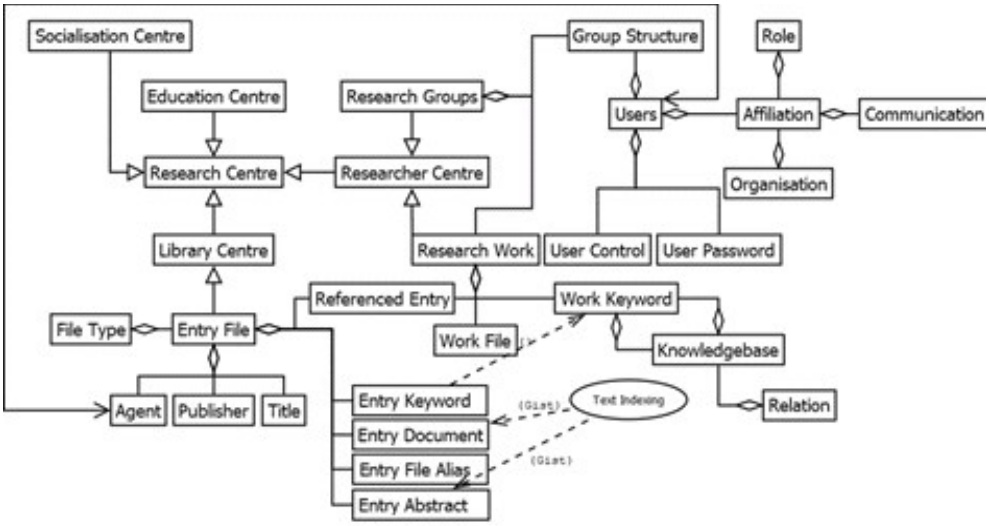

Figure 3 LMS structure

This many-to-many structure poses a high complexity in research activity management. By consequence, the embedded actions of *cooperation* and *collaboration* should support a much more complex relationship, and the *research centre* should adequately reflect the described complex structure.

The solving method consists of two entities named *research groups* and *group structure* (*Figure 3*). The keyword of *research groups* represents a reflexive, anti-symmetric and non-transitive construction, enabling a complex structure definition in the defined context. The *group structure* materialises the association between authenticated users and one or more teams. A specified user, along with a determined affiliation (affiliation is a tuple of {Organisation, Role}, *Figure 3*) can be a member of one or many of the *research teams* or *groups*. Obtaining success is, therefore, a perdurant entity of type *process*, and the proposed LMS intends to control the management of such a complex process. The proposed structure is also able to support an early verification of *scientific dishonesty*.

The Knowledge Base, Cooperation, Collaboration and Awareness

The process of research starts with a literature assessment. The extracted keywords entity is a tuple of {Keyword, Definition, Reference}. The extracted relations follow the structure in *Equation (1)*. The tuple of {extracted keyword, extracted relations} forms the knowledge base.

Regarding the source of information, the proposed LMS should preserve the ownership of reviewed references. One specialisation over the managed information needs to be present in this framework to control the dishonesty that may occur, even without awareness of the implied actors.

The topic of *cooperation and collaboration* represents a central concern for a doctoral programme. However, the literature shows that the participants' awareness usually is seen as a challenge for the doctoral programme, e.g., the domain of *scientific dishonesty*. The problem arising here is how to increase awareness and preserve the authorship credentials over the research outcomes. Even more, awareness overpasses the *research team* boundaries.

The doctoral school members should be able to access the required information regarding different actors and their research outcomes with impact on the domain of *cross-disciplinarity*.

Building the Knowledge Base

The process of research starts with a literature assessment for the selected domains of interests. Two categories of entities account for knowledge formation in this stage. The extracted keywords represent the first category. This entity is a tuple of {Keyword, Definition, Reference}. The specific extracted relations represent the second category. The two classes here, seen in aggregation, form the knowledge base.

The keywords extraction counts on the assessed literature. Regarding the source of information, the proposed LMS should preserve the ownership of reviewed references. One specialisation over the managed information needs to be present in this framework to control the dishonesty that may occur, even without the awareness of the implied actors. A specific taxonomy follows to control the granting procedure against the recorded references.

The difference highlighted in *Table 2* between keywords (as published) and keywords (as extracted) is essential, and we should be aware of it. The first term represents an indexing term as proposed by authors and used by publishers; the second represents the extracted terms proposed by researchers as a conceptual representation of knowledge. With the second one, specific operations would be considered to define the term of the *knowledge base*.

Table 2 Public versus Non-Public Information

Information type	Create and Update Grant to	Read (Download) Grant to
Title, Authors, Publisher, Year	Non-transitive over the entry file record owner	Public
Abstract	Non-transitive over the entry file record owner	Public
Keywords (as published)	Non-transitive over the entry file record owner	Public
Extracted keywords (for	Transitive over the	Public

ongoing research activity)	research team group	
Extracted relationship (of continuing research activity)	Transitive over the research team group	Public
Entry file	Non-transitive over the entry file record owner	Transitive over the research team group
Gist (meaning), themes (concepts) and tokens (used words)	Non-transitive over the entry file record owner	Public

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