# Curriculum Harmonization in educational organizations with the project management Quintessence kernel

Antonio Vera
Universidad Nacional de Colombia
avera@unal.edu.co

Carlos Mario Zapata-Jaramillo
Universidad Nacional de Colombia
cmzapata@unal.edu.co

## ABSTRACT

*Educational organizations aim to improve institutional capabilities by enhancing their curriculum programs. Therefore, colleges and universities include curriculum harmonization processes for complying with international homologation programs. Such programs are meant for standardizing quality assurance in formal education according to international regulations. However, institutions perform different harmonization practices for each educational department, lacking standardization in the process. Besides, the implementation and long-term substance for harmonizing curriculum programs are unpredictable due to the uncertainty about the activities, responsibles, and output work products needed for the harmonization success. In this paper we propose a representation for harmonizing and accrediting—according to an international accreditation board organization—the Requirements Engineering course—which is part of a Systems Engineering curricular program—in any formal educational institution. The representation is based on the Quintessence kernel, which serves as a neutral domain for evidencing harmonization in curricular programs. Our multidiscipline solution is aimed to consolidate formal, reusable, adaptable, and graphical constructs allowing educational organizations for starting curricular harmonization initiatives.*

## INTRODUCTION

Colleges and universities search for restructuring training programs for providing initial competencies for undergraduate students (Smulders et al, 2006). According to Jarm et al. (2014), "there is a strong pressure on education, training, and life long learning programs to continuously adapt their objectives in order to face new requirements and challenges." Consequently, higher educational institutions continuously enhance their practices for achieving such requirements.

Educational organizations are concerned with the implementation/development of international standards in different contexts for globalization purposes (Teodorczuk & Morris, 2018). The will to synchronize with international models leads education towards such standards (Gorga, 2007). Therefore, international harmonization of educational curriculum programs is implemented as a form of globalization, since a harmonized curriculum can be implemented in cross-cutting environments. Harmonization measures enhance comparability, mutual participation, exchange, and cooperation (Micheuz, 2008). According to Van der Aa et al. (2019), harmonization "is regarded as the establishment of common standards in education, while maintaining regional or local freedom to adapt training to contexts." Consequently, formal educational institutions seek international college/university homologation program accreditors for harmonizing and standardizing their curriculum programs according to international quality regulations.

Previous studies have been performed for evaluating harmonization in educational areas such as healthcare, informatics, neurology, mathematics, biology, information/communication technology, computer systems, and others (Bion & Barrett, 2006; Loddenkemper et al., 2006; Luciak-Donsberger et al., 2009; Anohina, & Grundspenkis, 2008; Micheuz, 2008; Prepelita-Raileanu & Pirvan, 2011; Smulders et al., 2012; Struhala et al., 2013; Komenda et al., 2014; Beqiri & Tolaj, 2015; Komenda et al., 2015; Van der Aa et al., 2016; Mandić, 2018; Van der Aa et al., 2019). Nevertheless, each institution/department applies different harmonization methods for accrediting its curriculum programs. Besides, differences between contextualization and standardization emerge when harmonizing curriculum programs (Van der Aa, 2019). Micheuz (2008) recognizes digital/computerized society development matches changing technologies and educational didactic approaches on all levels. Moreover, a common standard for education is like "a moving target" according to the author. Hawkins (2012) exposes harmonizing higher educational systems with regional organizations and partnerships is "easier said than done." The author is based on the ongoing European Union case and the Asian case. In such a case, the harmonization process remains uncertain despite regional organizations efforts, policies, and programs (Hawkins, 2012). In addition, Komenda et al. (2013) expose the lack of instruments for covering elements associated with global curriculum harmonization.

In this paper we propose a formal representation for harmonizing the Requirements Engineering course which is part of a Systems Engineering curricular program. We aim to achieve the learning outcomes requested by the Accreditation Board for Engineering and Technology (ABET) organization in order to accredit such a course. The solution is based on the multidiscipline project management Quintessence kernel (Henao, 2018). Such a kernel is meant for improving the way practitioners track projects health and progress. Besides, Quintessence can be agnostic to any method or practice due to the universal nature of its patterns and components.

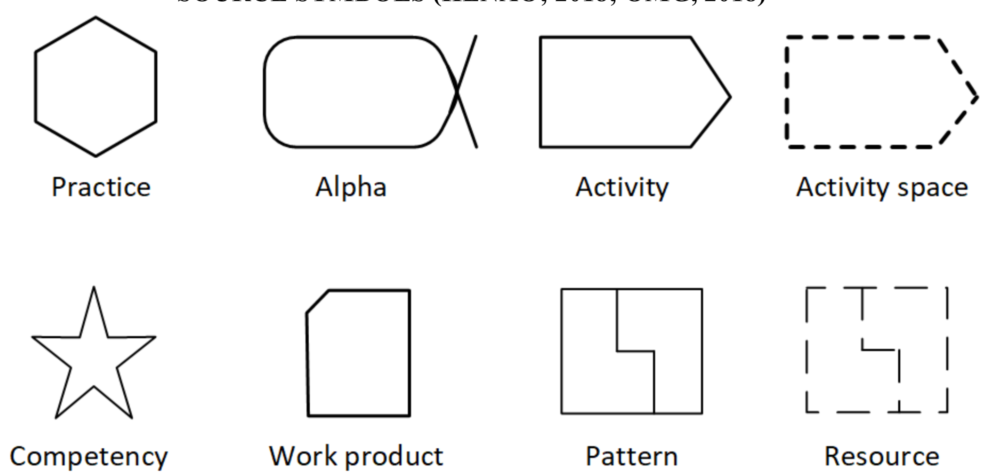
This study is aimed to improve traditional methods for harmonizing curriculum programs according to international accreditation organizations. The theoretical constructs implemented for harmonizing the Requirements Engineering course can be scaled to the remaining courses included in the Systems Engineering curricular program. Besides, such theoretical constructs can be applied to other disciplines for harmonizing any curriculum programs. Finally, the multidiscipline, formal, reusable, adaptable, and graphical representation proposed in this paper contributes for orientating formal educational organizations when accrediting their curriculum programs according to international standards.

This paper is organized into three sections. First, we provide theoretical framework regarding the constructs implemented in the solutions. Then, we demonstrate the harmonization of a curricular program by implementing components of the Quintessence kernel. Finally, we discuss the findings of this research and make suggestions for future research.

## THEORETICAL FRAMEWORK

The project management Quintessence kernel (Henao, 2018) is based on Essence (OMG, 2018) and it includes universal elements usable in multidiscipline environments. The kernel involves a set of elements used to form a common ground for describing a project endeavor. Such a kernel is used to develop repeatable practices for doing something with a specific objective. The Quintessence kernel inherits the Essence kernel properties. Therefore, Quintessence is scalable, extensible, and easy to use allowing practitioners to describe the essentials of their existing and future methods/practices so they can be compared, evaluated, tailored, used, adapted, simulated, and measured (OMG, 2018). In addition, the kernel is meant to continually assess the progress and health of the project efforts. The Quintessence kernel includes three codifying patterns: (i) the dimensionality pattern for defining the project management dimensions; (ii) the process-definition pattern for defining the set of actions when creating a product/service; and (iii) the process-grouping pattern for grouping in a categorical way actions when creating a product/service. The kernel includes a set of elements needed for representing methods/practices as shown in Exhibit 1.

**EXHIBIT 1**
**PRACTICE, ALPHA, ACTIVITY, ACTIVITY SPACE, COMPETENCY, WORK PRODUCT, PATTERN, AND RESOURCE SYMBOLS (HENAO; 2018; OMG, 2018)**




The kernel includes a collection of three areas of concern to which practitioners should pay attention when defining the endeavor (see Exhibit 2; Henao, 2018).

Quintessence includes a set of project dimensions to run and manage projects known as alphas (abstract level progress health attribute) universal to all project management disciplines as shown in Exhibit 3 (Henao, 2018).

Each area of concern has activity spaces which are placeholders for including activities to be performed and complementing the alphas (see Exhibit 4; Henao, 2018).

The Quintessence kernel includes the competencies presented by Durango and Zapata (2019). The competencies are implemented for describing capabilities/skills required when performing a specific task (see Exhibit 5).

**EXHIBIT 2**
**QUINTESSENCE AREAS OF CONCERN (HENAO; 2018; OMG, 2018)**

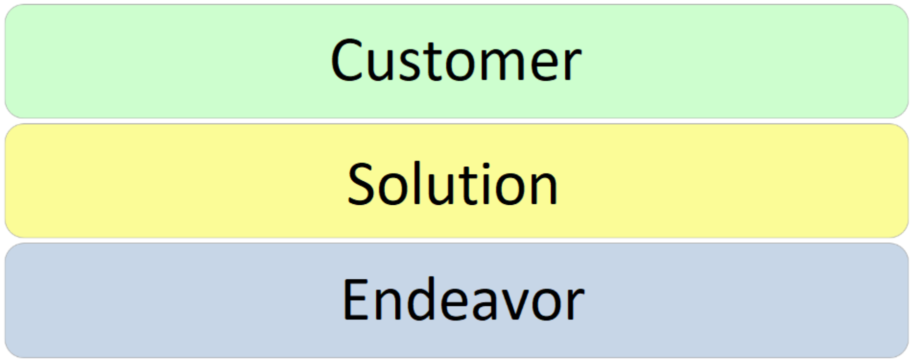



**EXHIBIT 3**
**PROJECT MANAGEMENT QUINTESSENCE KERNEL ALPHAS (THE AUTHORS BASED ON HENAO, 2018)**

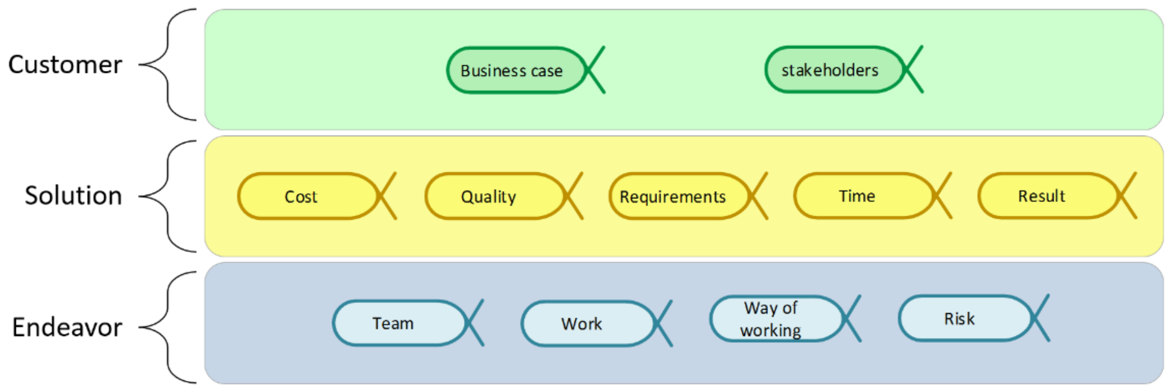



**EXHIBIT 4**
**PROJECT MANAGEMENT QUINTESSENCE KERNEL ACTIVITY SPACES (HENAO, 2018)**

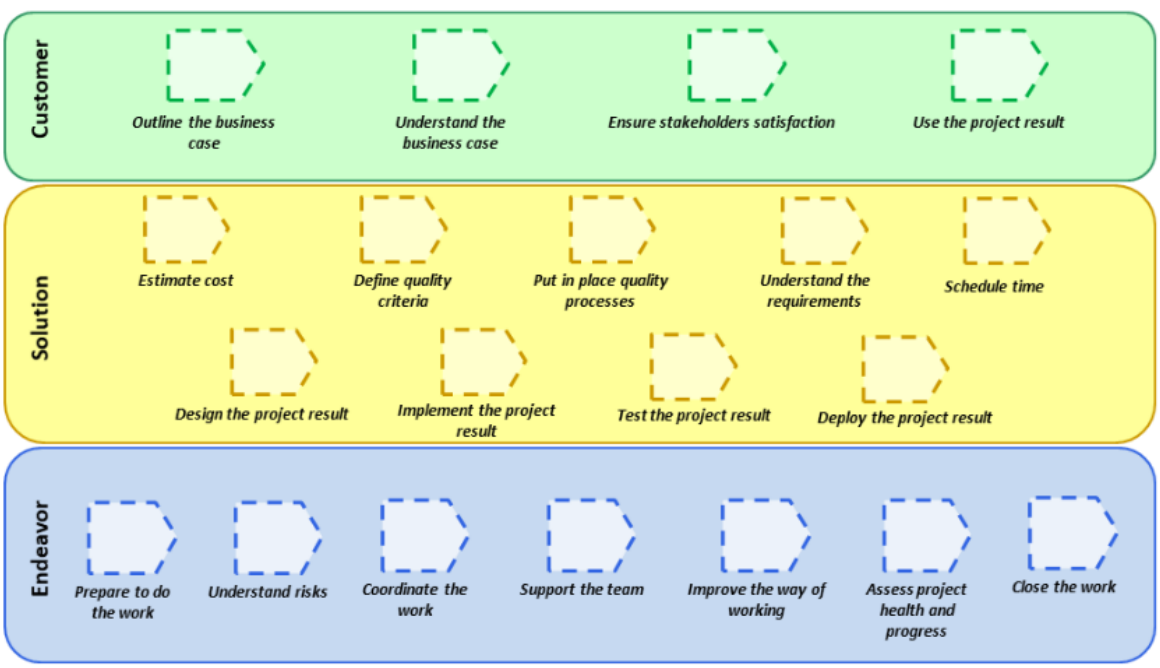
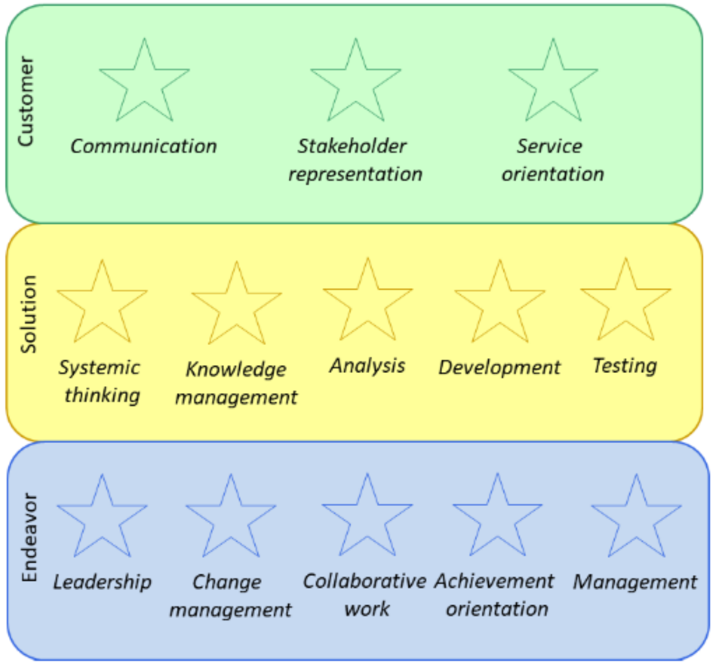


**EXHIBIT 5**
**DURANGO AND ZAPATA COMPETENCIES (2019)**




## HARMONIZING A CURRICULAR PROGRAM WITH QUINTESSENCE

Educational institutions are required to acquire the accreditation status of each program accurately and unambiguously. Completion criteria for addressing harmonization requirements of each program degree level are verified, validated, and accredited by international commissions. The core objectives of such accreditation are: (i) comply with governmental/international standards; and (ii) ensure educational programs meet the quality excellence for producing graduates prepared to enter a global workforce. Therefore, colleges and universities must demonstrate learning outcomes along with the curriculum program for ensuring compliance with all accreditation criteria and policies.

In this paper we demonstrate how to harmonize practices of a singular course—Requirements Engineering—which is part of a Systems Engineering curricular program. We aim to comply with learning outcomes requested for international accreditation in engineering sciences. We harmonize the abilities gained from the Requirements Engineering course with the learning outcomes established by ABET. ABET is a non-governmental recognized U.S. accreditor of college and university programs in applied and natural science, computing, engineering, and engineering technology (ABET, n.d.).

The learning outcomes requested by ABET for accrediting engineering programs in 2021–2022 are described as follows (ABET, n.d.):

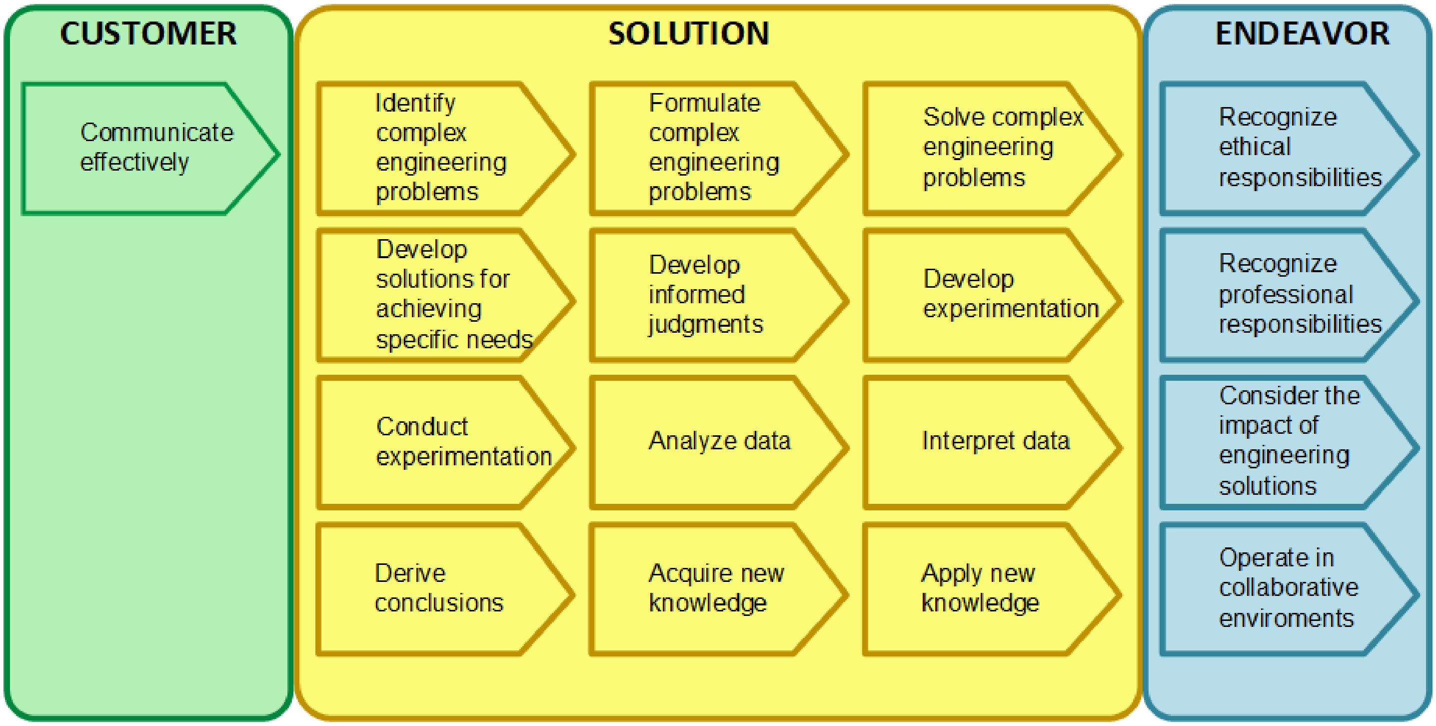
- “An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics”
- “An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors”
- “An ability to communicate effectively with a range of audiences”
- “An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts”
- “An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives”
- “An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions”
- “An ability to acquire and apply new knowledge as needed, using appropriate learning strategies”

In addition, each course can promote specific learning outcomes depending on its nature and specific program educational objectives. Therefore, an additional learning outcome of the course Requirements Engineering is resume as follows:

- An ability for eliciting requirements from stakeholders in multiple knowledge areas for shaping, implementing, testing, deploying, and operating software systems for ensuring stakeholder satisfaction when using such systems

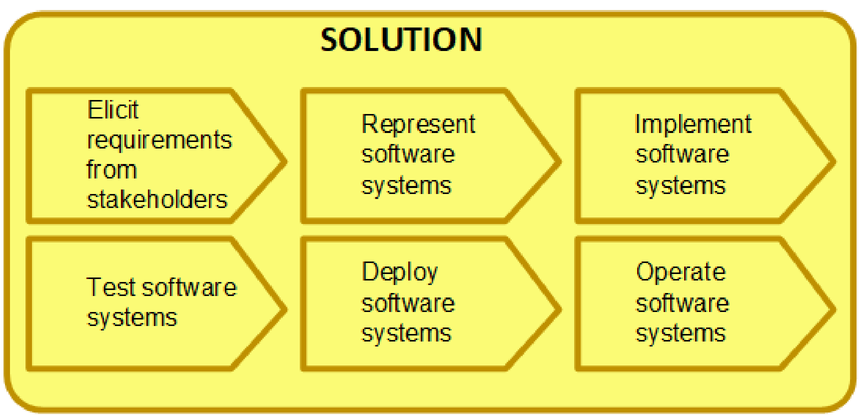
We represent the activities—discriminated by each area of concern—an engineer must perform for demonstrating the learning outcomes in Exhibit 6.

**EXHIBIT 6**
**ACTIVITIES TO PERFORM FOR DEMONSTRATING MINIMUM ENGINEERING *LEARNING OUTCOMES***
**(SOURCE: THE AUTHORS)**




Additional activities for demonstrating the learning outcomes of the Requirements Engineering course are shown in Exhibit 7.

**EXHIBIT 7**
**ADDITIONAL ACTIVITIES OF THE *REQUIREMENTS ENGINEERING* COURSE *LEARNING OUTCOMES***
**(SOURCE: THE AUTHORS)**




Practitioners must apply the resources shown in Exhibit 8 for accomplishing the harmonization activities.

The execution of activities for demonstrating learning outcomes can produce output work products as illustrated in Exhibit 9.

The competencies needed for acquiring the engineering *learning outcomes* are shown in Exhibit 10.

**EXHIBIT 8**
**RESOURCES FOR SUCCEEDING IN ENGINEERING *LEARNING OUTCOMES* ACTIVITIES**
**(SOURCE: THE AUTHORS)**

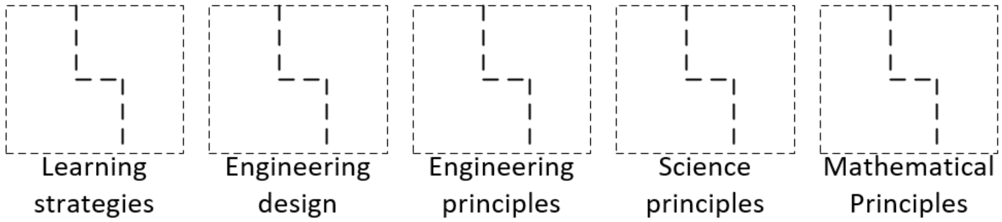
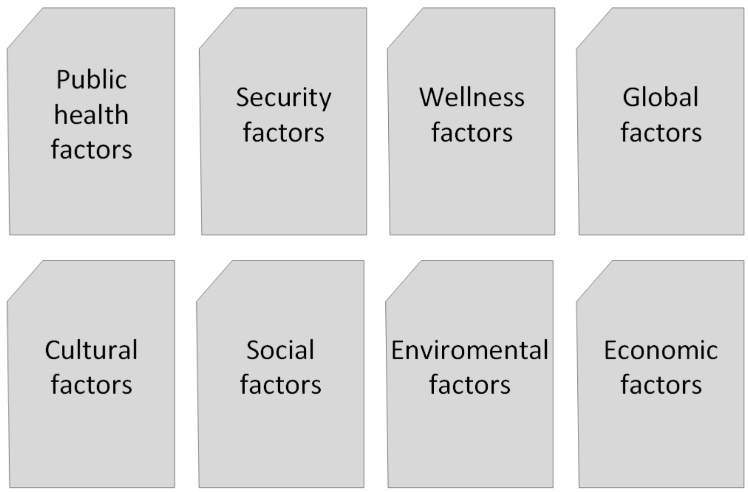



**EXHIBIT 9**
**WORK PRODUCTS RESULTING FROM ENGINEERING *LEARNING OUTCOMES* ACTIVITIES**
**(SOURCE: THE AUTHORS)**




The Requirements Engineering course allows practitioners for performing an elicitation lifecycle process. Such a process starts with the early planning of the endeavor as shown in Exhibit 11. The project manager works on defining roles and responsibilities. Therefore, the practitioner recognizes professional responsibilities complying with the activity necessary for achieving a learning outcome. Then, the project manager explains to the team the working method to be performed in the elicitation exercise. Consequently, the practitioner operates in collaborative environments complying with a new learning outcome activity. The next practice is performed by the analyst and involves the discourse-based modelling of the opportunity as presented in Exhibit 12. The analyst reviews the documentation, conducts interviews along with the stakeholders, identifies organizational agents, identifies organizational processes, establishes a common vocabulary, and verifies the consistency. Hence, the practitioner communicates effectively, identifies complex engineering problems, solves complex engineering problems, analyzes data, interprets data, derives conclusions, considers the impact of engineering solutions, and elicits requirements from stakeholders complying with several learning outcomes activities.

The learning outcomes acquired by performing the Requirements Engineering practices used in this exercise can be harmonized with a curriculum program standard as presented in Exhibit 13.

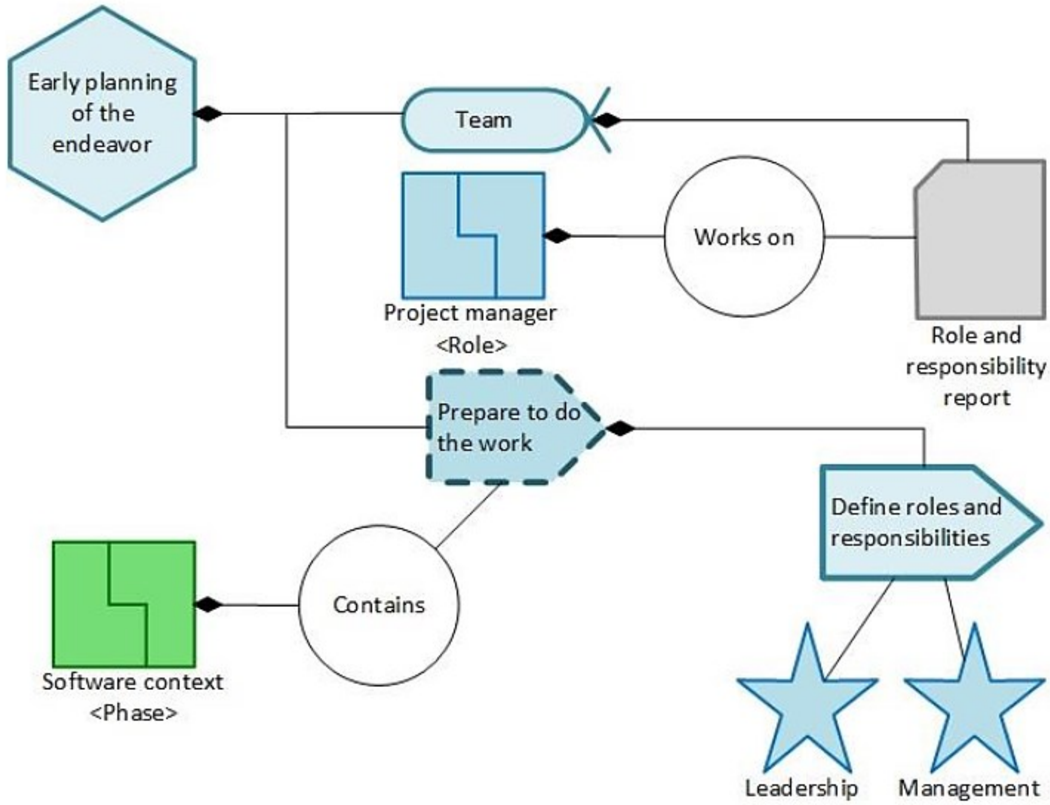
## CONCLUSIONS

A novel representation for harmonizing curriculum programs was proposed in this paper. The solution is developed with components based on the project management Quintessence kernel. The representation is meant to be a solution for curriculum mapping issues by making study programs harmonized with academic standards. In addition, the evidence presented in this paper supports the benefits practitioners can acquire when implementing the solution. The representation contributes to educational curriculum standardization knowledge, in particular, quality principles involving harmonization processes. Consequently, such a contribution is a constructive foundation for guiding higher educational institutions when standardizing curriculum programs along with international accreditation organizations.

The benefits achieved by implementing the solution represented in the project management Quintessence kernel can be understood in terms of the following aspects:

**EXHIBIT 10**
**COMPETENCES NEEDED FOR PERFORMING ENGINEERING *LEARNING OUTCOMES* ACTIVITIES**
**(SOURCE: THE AUTHORS)**

**EXHIBIT 11**
**REQUIREMENTS ENGINEERING COURSE PRACTICE: EARLY PLANNING OF THE ENDEAVOR (SOURCE: THE AUTHORS)**



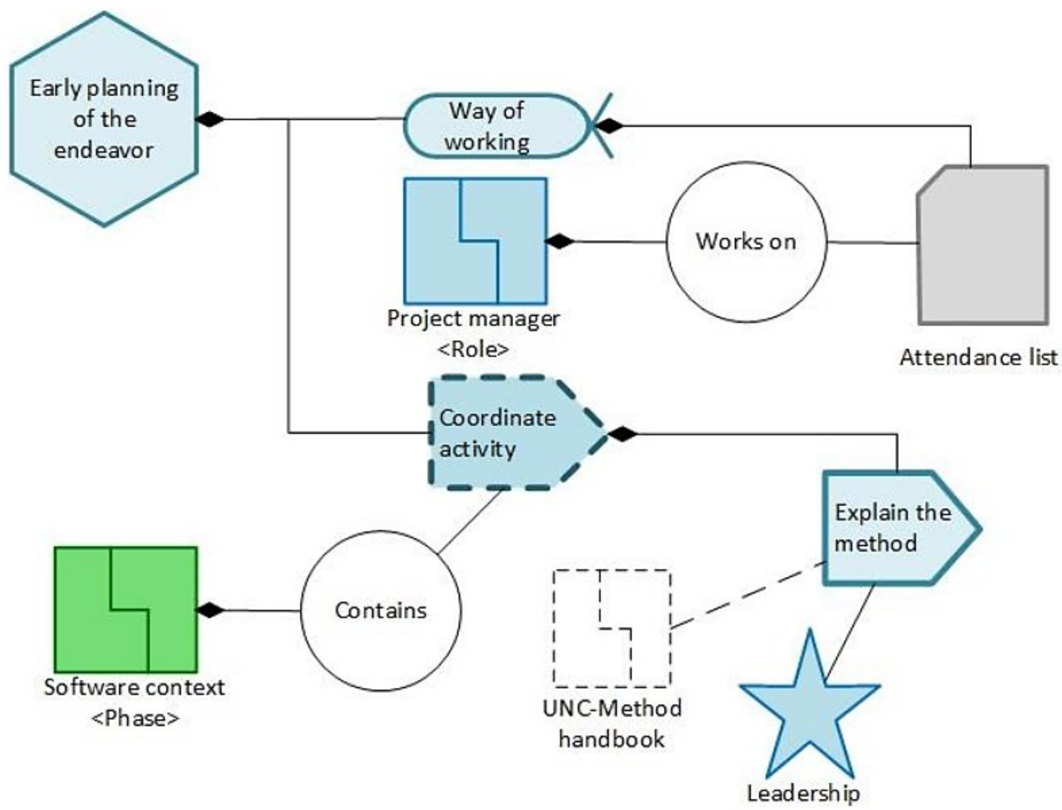
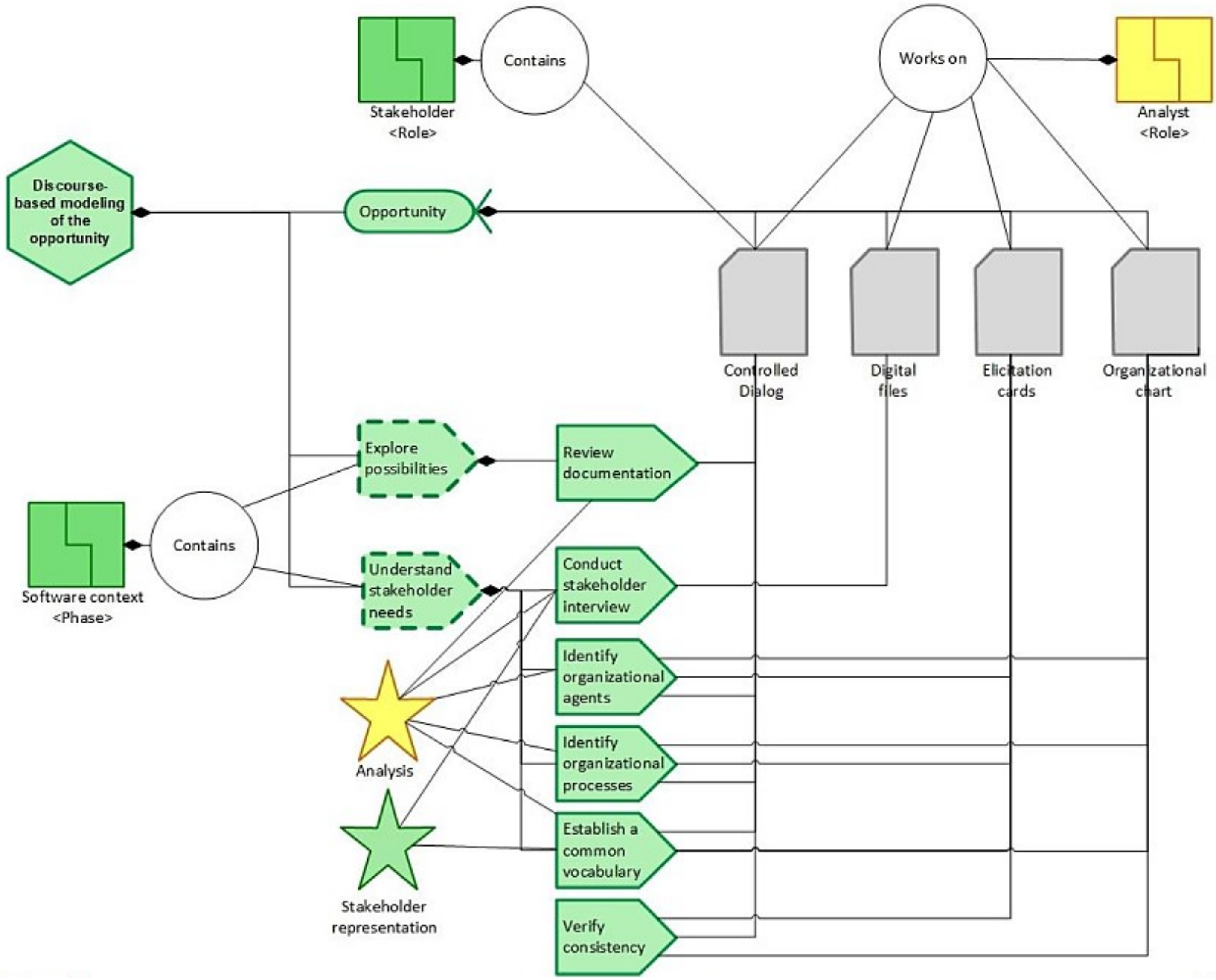



**EXHIBIT 12**
**REQUIREMENTS ENGINEERING COURSE PRACTICE: DISCOURSE BA SED MODELLING OF THE OPPORTUNITY**
**(SOURCE: THE AUTHORS)**




Multidisciplinary kernel: the solution supports multidisciplinary curriculum programs by covering universal elements usable in all driven disciplines. Here we exemplify with an engineering program, but we can select any other discipline.

Formal language: the Quintessence kernel includes structural patterns codified as a holistic multidimensional formal language.

Graphical representation: the solution is graphically represented by using components of the Quintessence kernel.

Adaptable/Reusable: the condition for implementing the solutions involves the representation of the courses in a specified curriculum program. Therefore, the representation is reusable and independent of other curriculum programs during the harmonization lifecycle.

Reduced gap between industry and academia: According to OMG (2018), the Essence kernel includes elements for reducing the gap between academic research and heuristic application in the industry. Consequently, we meant to fulfill the gap between industry and academia in educational harmonization terms by applying the Quintessence kernel—which is based on Essence.

In this research we proposed theoretical constructs for harmonizing the Requirements Engineering course in a Systems Engineering curricular program. Further study should consider the development of case studies for implementing such theoretical constructs in real-life harmonization processes involving courses and curricular programs in different disciplines. The outcomes of such case studies can reveal the effectiveness of the representation when international organizations evaluate curriculum harmonization evidence.

## REFERENCES


ABET. Accreditation Board for Engineering and Technology. *Criteria for Accrediting Engineering Programs, 2021 – 2022.* Retrieved November 5, 2021 from https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/

Anohina, A. & Grundspenkis, J. (2008). Harmonization of Engineering Education in Europe as a Prerequisite for Student Mobility: a Case Study Based on Curricula Modularity, *WSEAS Transactions on Advance in Engineering Education*, Vol. 7, No. 9, pp. 613–623.

Beqiri, E. & Tolaj, A. (2015). Harmonization of the Preuniversity Programs of Information and Communication Technology,

in compliance with EU market needs. In *Conference Proceedings - 5th International Conference - "Compliance of the Standards in South-Eastern European Countries with the Harmonized Standards of European Union"*, Peja.

Bion, J. & Barrett, H. (2006). Development of core competencies for an international training programme in intensive care medicine, *Intensive Care Med*, Vol. 32, pp. 1371–1383.

Durango, C. & Zapata, C. (2019). Representación en el núcleo de la esencia de Semat de las Competencias de un Equipo de Desarrollo de Software, *Información tecnológica*, Vol. 30, No. 4, pp. 217–226.

Gorga, A. (2007). Where Are We with the Harmonization of European Higher Education?: The Case of Central and East European Countries, *European Education*, Vol. 39, No. 4, pp. 58–68.

Hawkins, J. N. (2012). Regionalization and harmonization of higher education in Asia, *Asian Education and Development Studies*, Vol 1, No, 1, 96–108.

Henao, A. (2018). *Towards a theory for defining a project management multidisciplinary kernel: An approach based on Abstract Level Progress Health Attributes* (M.Sc. Thesis), Universidad Nacional de Colombia, Colombia.

Jarm, T., Pallikarakis, N., Miklavcic, D., & Magjarevic, R. (2014). Proposal for Generic Biomedical Engineering Programs Based on European Experience, In: Jobbágy Á. (Ed), *5th European Conference of the International Federation for Medical and Biological Engineering*, IFMBE Proceedings, Vol 37. Springer, Berlin, Heidelberg.

Komenda, M., Schwarz, D., Švancara, J., Vaitsis, C., Zary, N., & Dušek, L. (2015). Practical use of medical terminology in curriculum mapping, *Computers in Biology and Medicine*, Vol. 63, pp. 74–82.

Komenda, M., Víta, M., Vaitsis, C., Schwarz, D., Pokorná, A., Zary, N., & Dušek, L. (2015). Curriculum Mapping with Academic Analytics in Medical and Healthcare Education, *PLOS ONE*, Vol. 10, no. 12, pp. 1–18.

Komenda, M., Schwarz, D. & Dušek, L. (2013). Building platform for optimization of medical education. In *EFMI STC: Sharing Knowledge and Tools for Decision Support in Biomedicine and Health Care*, Prague.

Komenda,M., Schwarz, D., Hřebíček, J., Holčík, J., & Dušek, L. (2014). A Framework for Curriculum Management The Use of Outcome-based Approach in Practice, In *Proceedings of the 6th International Conference on Computer Supported Education*, pp. 473–478.

Loddenkemper, R., Severin, T., Eisele, J., & Haslam, P. (2006). HERMES: good reasons for harmonising education and training in respiratory medicine, *European Respiratory Journal*, Vol. 28, pp. 470–471.

Luciak-Donsberger, C., & Eaton, K. (2009). Dental hygienists in Europe: trends towards harmonization of education and practice since 2003, *International Journal of Dental Hygiene*, Vol. 7, No. 4, pp. 273–284.

Mandić, M. (2018). Semantic Web based software platform for curriculum harmonization, In *Proceedings of the 8th International Conference on Web Intelligence, Mining and Semantics*, Novi Sad.

Micheuz, P. (2008). Harmonization of Informatics Education – Science Fiction or Prospective Reality?, In: R.T. Mittermeir and M.M. Sysło (Eds.), *International Conference on Informatics in Secondary Schools - Evolution and Perspectives*, pp. 317–326.

OMG (2018). *Essence - kernel and language for software engineering methods version 1.2*, standard.

Prepelita-Raileanu, B & Pirvan, M. (2011). Procedures of Developing and Harmonization of the Curriculum for the Mathematical Disciplines Taught in Higher Technical Education, *Recent Researches in Educational Technologies*, pp. 94–99.

Smulders, F., Buncic, S., Fehlhaber, K., Huey, R., Korkeala, H., Prieto, M., & Steinhauserova, I. (2012). Toward Harmonization of the European Food Hygiene/Veterinary Public Health Curriculum, *Journal of Veterinary Medical Education*, Vol. 39, No. 2, 169–179.

Struhala, W., Mellgrenb, S., & Grisoldc, W. (2013). Three important steps to European neurology harmonization: core curriculum, visitation program, European board examination, *European Journal of Neurology*, Vol. 20, pp. 101–104.

Teodorczuk, A. & Morris, C. (2018). Time to CHAT about globalization, *Medical Education*, Vol. 53, No. 1, pp. 3–5.

Van der Aa, J., Goverde, A., Teunissen, P., & Scheele F. (2016). Paving the road for a European postgraduate training curriculum. *European Journal of Obstetrics and Gynecology and Reproductive Biology*. Vol. 203, pp. 229–231.

Van der Aa, J., Scheele, F., Goverde, A., & Teunissen, P. (2019). A qualitative study on harmonization of postgraduate medical education in Europe: negotiating flexibility is key, *Perspectives on Medical Education*, Vol. 8, pp. 216–222.