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Curriculum harmonization with *ESSENTIA CURRICULUM*: An approach applied to the education system at the University of Nariño

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Abstract: Balancing broad learning outcomes in graduate programs with detailed classroom learning outcomes is increasingly crucial in education systems. This study employs a qualitative paradigm through a case study method to address the gap between learning outcomes at the graduate program level and those at the course level. Using the *ESSENTIA CURRICULUM* framework—a curriculum design methodology derived from software engineering practices—we propose an innovative and adaptable approach for aligning program-wide and course-specific learning outcomes. The *ESSENTIA CURRICULUM*, named for its focus on the “essence of the curriculum”, is applied to the ICT for Research course within the M.Sc. program in University Teaching at the University of Nariño. This framework fosters a consistent educational journey centered on learning achievements and demonstrates its effectiveness through a comprehensive self-assessment process and stakeholder feedback. The implications of this research are twofold: it highlights the potential of adopting interdisciplinary methodologies for curriculum design and provides a scalable and alternative strategy for harmonizing learning outcomes across diverse educational contexts. By bridging principles from software engineering into education, this novel approach offers new avenues for improving curriculum coherence and applicability.

Keywords: *ESSENTIA CURRICULUM*; learning outcomes; curriculum; harmonization

1. Introduction

In today’s rapidly evolving educational landscape, aligning the broad learning outcomes of academic programs with the detailed objectives of individual courses is both essential and challenging (van der Aa et al., 2019). The macro perspective of curriculum design establishes overarching goals that serve as a blueprint, much like the foundational plans for constructing a building. However, ensuring that the micro-level elements—such as course syllabi and specific learning objectives—contribute effectively to these overarching goals remains a persistent challenge. This misalignment often results in fragmented learning experiences, with students struggling to achieve the intended broader educational standards (Margot and Kettler, 2019).

The need for an innovative curriculum design framework arises from these challenges. Frequent mismatches between program-level outcomes and course-level objectives disrupt the cohesion of educational pathways and hinder students’ progress. Traditional curriculum design methods, while useful in some contexts, often lack the adaptability required to address these complex and interconnected issues (Vera and Zapata-Jaramillo, 2022). In this context, the *ESSENTIA CURRICULUM* framework was developed as a novel approach to curriculum harmonization, drawing inspiration

from software engineering modeling practices (Insuasti, 2024). This framework addresses the urgent need for a systematic method to align learning outcomes across educational tiers, fostering coherence and adaptability in curriculum design.

ESSENTIA CURRICULUM comprises several key components that collectively facilitate the harmonization process. It is grounded in a controlled, context-free language that ensures clarity and consistency in representing learning outcomes. The framework organizes work into three primary areas of concern: customer, solution, and endeavor, which collectively address stakeholder needs, define the curriculum's scope, and outline the steps for implementation. Within these areas, the framework incorporates ALPHAs—abstracted elements representing core curriculum design components—and activity spaces that describe the steps required to achieve specific objectives. These components enable curriculum designers to systematically align course-level learning outcomes with program-level objectives, ensuring a cohesive educational journey.

This study employs the *ESSENTIA CURRICULUM* framework to align the learning outcomes of the Information and Communication Technologies (ICT) for Research course with the overarching goals of the M.Sc. program in University Teaching at the University of Nariño. By bridging the gap between micro- and macro-level objectives, this approach not only enhances curriculum coherence but also addresses the broader implications for curriculum design in diverse educational contexts.

The outcomes of this research demonstrate how a well-defined and structured framework like *ESSENTIA CURRICULUM* can resolve curriculum alignment challenges and inform the development of scalable educational solutions. The structure of this article is as follows: the second section reviews relevant literature; the third section details the methods and materials; the fourth section presents the proposed solution and its validation; the fifth section provides conclusions; and the last section outlines future research directions.

2. Literature review

We explore some studies with this literature review, delving into curriculum harmonization across various levels and regions, underscoring the opportunities and challenges inherent in this process.

The OPTIMED platform, described by Komenda et al. (2015), offers a web-based tool for harmonizing medical and healthcare education curricula with an outcome-based approach. This platform allows curriculum designers to efficiently organize courses and identify overlaps, enhancing transparency and continuity for users within the academic community. However, harmonizing curricula, especially in medical and healthcare education, still has challenges like achieving consensus among diverse stakeholders, each with their priorities and perspectives. Additionally, the integration of outcome-based approaches requires substantial alignment of learning objectives, which can be hindered by existing institutional silos and varying accreditation standards. Technical barriers, such as data interoperability and the need for robust IT infrastructure, further complicate the implementation of comprehensive platforms like OPTIMED. Finally, continuous updates and maintenance demand considerable time

and resources, posing an ongoing challenge for curriculum designers and administrators striving to keep educational content relevant and aligned with evolving professional standards.

Transitioning from the optimization of medical curricula, Cahapay (2020) proposes a preliminary analysis for developing a set of competencies for teacher education by harmonizing various curriculum sources in the ASEAN region. The study identifies unique, common, and differing expectations of teachers, suggesting a framework for enhancing curriculum design across diverse educational systems. Despite the promising framework proposed by Cahapay (2020), harmonizing teacher education curricula across the ASEAN region faces some obstacles in reconciling the diverse educational philosophies and pedagogical approaches in different countries. Additionally, variations in teacher qualifications, training standards, and certification requirements harden the process of establishing a unified set of competencies. Cultural differences and language barriers exacerbate such difficulties, challenging the creation of a cohesive curriculum according to local contexts and regional coherence. Moreover, the dynamic nature of educational policies and the varying pace of reforms across member states require continuous dialogue and adaptability, demanding extensive collaboration and resource allocation. Such complexities underscore the need for flexible and context-sensitive strategies in pursuing curriculum harmonization in teacher education.

Berutu et al. (2024) study the need for harmonized approaches to evaluate the effectiveness of an outcome-based education (OBE) curriculum at the Universitas Negeri Medan Faculty of Social Sciences. The positive stakeholder responses highlight the curriculum alignment with student needs and graduate requirements, underscoring the benefits of harmonization in enhancing educational quality. While the study by Berutu et al. (2024) demonstrates the benefits of an OBE curriculum, the harmonization process presents some challenges. Achieving uniformity in curriculum design requires extensive coordination among faculty members, who may have opposite views on educational priorities and methods. Additionally, aligning the curriculum with diverse student needs and varying graduate requirements demands a flexible yet coherent framework, which can be challenging to establish and maintain. Resistance to change from educators and administrators, who may be accustomed to traditional teaching methods, further complicates the implementation of OBE. Furthermore, ensuring the harmonized curriculum remains adaptable for future trends and job market demands requires continuous evaluation and updates, posing an ongoing challenge. Such obstacles highlight the complexities of harmonizing educational curricula despite their clear educational quality and relevance advantages.

Ball et al. (2007) compare the diversity in demographics, motivations, and career aspirations among international pharmacy students in some countries. The findings stress the need for tailored academic orientation and course development to accommodate demographic and motivational diversity, suggesting that curriculum harmonization can extend beyond regional confines to address global educational needs. Despite the insightful findings by Ball et al. (2007) on the need for tailored academic orientation, the harmonization of pharmacy curricula to accommodate global diversity presents some difficulties. One significant area for improvement is the wide variation in educational backgrounds and preparedness levels among

international students, hardening the design of a one-size-fits-all curriculum. Additionally, differing regulatory and accreditation standards across countries can hinder the development of a universally accepted curriculum. Students' diverse motivations and career aspirations require flexible and adaptable course structures, which can be resource-intensive to develop and maintain. Furthermore, achieving buy-in from educational institutions across countries with established norms and practices can be formidable. Such complexities underscore the difficulties in extending curriculum harmonization beyond regional boundaries to address global educational needs effectively.

Ebako and Molindo (2023) discuss the challenges of harmonizing primary education curricula in Cameroon's bicultural regions. Their findings emphasize the importance of integrating cultural diversity within the educational framework, indicating harmonization should aim at educational uniformity and respect local cultural patrimonies. Even with the importance of integrating cultural diversity within educational frameworks, as Ebako and Molindo (2023) discussed, harmonizing primary education curricula in Cameroon's bicultural regions presents several challenges. One significant difficulty is balancing the need for educational uniformity with the preservation of local cultural patrimonies, which often have distinct languages, traditions, and values. This balance requires extensive consultation and collaboration among some cultural groups, which can be time-consuming and complex.

Additionally, some resistance is expected from local communities who fear that a standardized curriculum could erode their cultural identity. The logistical challenges of implementing a harmonized curriculum across diverse and often remote regions further complicate the process. Such challenges highlight the intricate task of harmonizing curriculum and respecting and incorporating cultural diversity while striving for educational coherence and quality.

Munadi et al. (2021) evaluate the curriculum of Islamic Religious Education in Indonesia in the context of higher education, highlighting the need for educational flexibility. They suggest enhancing content knowledge in Islamic education as crucial for effectively meeting educational and societal needs. While Munadi et al. (2021) emphasize the importance of enhancing content knowledge in Islamic Religious Education, harmonizing such curricula in Indonesia's higher education system faces some challenges. One major issue is the inherent lack of educational flexibility, which can stifle incorporating contemporary and interdisciplinary perspectives for addressing modern societal needs. Balancing traditional religious teachings with progressive educational practices requires careful consideration and often encounters resistance from conservative stakeholders.

Additionally, the diverse interpretations of Islamic teachings across different regions and institutions can complicate the establishment of a unified curriculum. The need for continuous professional development in educators to effectively deliver an enriched curriculum also demands significant resources and institutional support. Such challenges underscore the complexities involved in achieving a harmonized Islamic Religious Education curriculum; such a curriculum should be both comprehensive and adaptable for evolving educational and societal contexts.

Bezic et al. (2020) explore how the Faculty of Economics and Business Rijeka aligns its curriculum with the demands of the Fourth Industrial Revolution, expanding to the broader implications of curriculum harmonization. So, they illustrate the critical role of higher education in preparing students for a rapidly changing economic landscape, further advocating for enhanced curriculum harmonization. While Bezic et al. (2020) underscore the importance of aligning curricula with the demands of the Fourth Industrial Revolution, harmonizing higher education curricula presents some difficulties. One significant difficulty is keeping pace with the rapid technological advancements and their implications for the economic landscape, which requires continuous updates and revisions to the curriculum. Additionally, integrating new and emerging fields into existing curricula requires substantial resource allocation and faculty training, which can be time-consuming and costly. Achieving consensus among educators and industry stakeholders on the necessary skills and knowledge further complicates the process. Moreover, ensuring the harmonized curriculum remains flexible enough to adapt to future changes while maintaining academic rigor poses an ongoing challenge. Such difficulties highlight the complexities of preparing students for a dynamic economic environment with enhanced curriculum harmonization.

Alemu (2023) presents the internationalization of African higher education institutions, focusing on the barriers and benefits of fostering South-South partnerships. The study highlights the need to leverage indigenous approaches to enhance the relevance and effectiveness of educational institutions. However, while Alemu (2023) highlights the benefits of internationalizing African higher education institutions through South-South partnerships, this harmonization process needs some help. One significant difficulty is overcoming the diverse educational policies and standards across different countries, which can impede the creation of a unified framework. Additionally, leveraging indigenous approaches requires a deep understanding and integration of local knowledge systems, sometimes misaligned with international standards. The logistical and financial constraints of fostering effective South-South collaborations can pose some barriers, as many institutions need more resources and infrastructure. Furthermore, some resistance to change is expected from stakeholders who are accustomed to traditional educational models. Such difficulties underscore the complexities involved in harmonizing curricula to enhance the relevance and effectiveness of African higher education institutions while fostering international collaboration.

Lokossou et al. (2021) evaluate the Field Epidemiology and Laboratory Training Program across West Africa. The study underscores the need for curriculum harmonization, accreditation of training institutions, and enhanced inter-country collaboration to meet regional health security challenges effectively. However, some difficulties hinder this process. One significant area for improvement is achieving uniform accreditation standards among diverse training institutions, which should have varying levels of resources and expertise. The complexity of aligning curricula across multiple countries with different health policies and regulations further complicates the harmonization effort.

Additionally, fostering enhanced inter-country collaboration requires coordination and communication, which logistical barriers and geopolitical tensions

can impede. Ensuring the harmonized curriculum remains adaptable for evolving regional health security challenges also demands continuous evaluation and updates. Such difficulties highlight the intricate task of harmonizing training programs to effectively address the region’s diverse and dynamic health security needs.

3. Materials and methods

Our research embraces a qualitative paradigm primarily focused on comprehending and interpreting intricate human behaviors, societal dynamics, and cultural phenomena. This approach contrasts with quantitative research, which aims to measure data with statistical means. Qualitative research delves into understanding underlying meanings, concepts, features, symbols, and descriptions (Fugard and Potts, 2015).

We utilize a case study method to examine specific instances within their real-world settings. Such studies may involve individuals, groups, events, organizations, or communities (Cousin, 2005). Specifically, we research curriculum harmonization within the ICT for Research course at the M.Sc. program in University Teaching at the University of Nariño, Pasto, southern Colombia.

We studied the alignment of course learning outcomes with overall program ones. By focusing on curriculum harmonization, we aim to discover how the processes ensuring the course content, teaching methods, and assessment strategies effectively contribute to the comprehensive development of students as per the program goals. Our findings highlight the challenges and opportunities in synchronizing individual course learning outcomes with broader learning outcomes by analyzing the syllabus, teaching practices, and student achievements. This case study includes valuable insights into curriculum development and alignment in engineering education.

With this in mind, we employ interpretative analysis to scrutinize textual documentation on the stated learning outcomes of the graduate program and the ICT for Research course syllabus.

The curriculum design process has significantly evolved, with various methods proposed based on a century of curriculum design theory, from Kilpatrick (1918) to Ornstein and Hunkins (2018), as depicted in **Table 1**.

Table 1. A century of curriculum design theory.

Authors	Method structure
Kilpatrick (1918)	<ol style="list-style-type: none"> 1. Purposing 2. Planning 3. Executing 4. Interpreting and Judging
Bobbitt (1924)	<ol style="list-style-type: none"> 1. Identifying a domain <ol style="list-style-type: none"> 1.1. Finding the experts 1.2. Analyzing the expert behavior 1.3. Characterizing the student profile and their role 2. Identifying the activities for such a domain 3. Proposing educational objectives for each activity <ol style="list-style-type: none"> 3.1. Objective-based steps 3.2. Preparing the material

Table 1. (Continued).

Authors	Method structure
Charters (1929)	<ol style="list-style-type: none"> 1. Job-functional analysis 2. Defining objectives 3. Building the structure to achieve the objectives 4. Operating the structure 5. Evaluate the results
Rugg (1930)	<ol style="list-style-type: none"> 1. Stating the objectives 2. Sequencing the experiences to achieve the objectives 3. Selecting the content 4. Stating the outcomes from the experiences
Caswell and Campbell (1935)	<ol style="list-style-type: none"> 1. Stating the principles 2. Determining the educational aims 3. Establishing the scope of the curriculum 4. Determining the student purposes 5. Setting up activities 6. Selecting subject matter 7. Grading policies 8. Choosing teaching procedures 9. Evaluating the outcomes 10. Organizing instruction.
Tyler (1949)	<ol style="list-style-type: none"> 1. Stating the educational objectives <ol style="list-style-type: none"> 1.1. Examining the context 1.2. Theoretical foundation 1.3. Objective-form statement 2. Selecting the learning experiences 3. Organizing learning experiences <ol style="list-style-type: none"> 3.1. Organizing threads 3.2. Organizing principles 3.3. Organizing structures 4. Evaluating the learning <ol style="list-style-type: none"> 4.1. Evaluating the results 4.2. Identifying the strengths and weaknesses of the plan 4.3. Planning the improvements
Smith et al. (1957)	<ol style="list-style-type: none"> 1. Determining the educational directions 2. Selecting and ordering the learning experiences 3. Selecting the pattern of curriculum organization 4. Evaluating and sustaining the curriculum
Taba (1962)	<ol style="list-style-type: none"> 1. Diagnosing the needs 2. Formulating the objectives 3. Selecting the content 4. Organizing the content 5. Selecting the learning experiences 6. Organizing the learning experiences 7. Evaluating
Kerr (1968)	<ol style="list-style-type: none"> 1. Curriculum objectives 2. Knowledge 3. Learning experiences 4. Curriculum evaluation
Nicholls and Nicholls (1972)	<ol style="list-style-type: none"> 1. Objectives <ol style="list-style-type: none"> 1.1. Analyzing the situation 1.2. Selecting the objectives 2. Methods and materials <ol style="list-style-type: none"> 2.1. Selecting and organizing the contents 2.2. Selecting and organizing the learning experiences 3. Assessment 4. Feedback

Table 1. (Continued).

Authors	Method structure
Stenhouse (1975)	<ol style="list-style-type: none"> 1. Selecting the content 2. Developing the learning strategies 3. Assessing the learning
Bruner (1977)	<ol style="list-style-type: none"> 1. Determining the learner interests 2. Setting up the aims of education 3. Setting up the aims of the specific topic 4. Selecting the large life experiences 5. Analyzing those life experiences
Walters (1978)	<ol style="list-style-type: none"> 1. The aims of the curriculum 2. The content 3. The methodics 4. The organization 5. The evaluation
Grayson (1978)	<ol style="list-style-type: none"> 1. Problem definition 2. Structuring the curriculum 3. Implementation and evaluation
Perkins (1998)	<ol style="list-style-type: none"> 1. Generative topics 2. Formulating the understanding goals 3. Performing the understanding 4. Assessing
Wiggins and McTighe (1999)	<ol style="list-style-type: none"> 1. Identifying desired results 2. Determining acceptable evidence 3. Planning learning experiences and instruction
Isman et al. (2005)	<ol style="list-style-type: none"> 1. Input 2. Process 3. Output 4. Feedback
van den Akker et al. (2006)	<ol style="list-style-type: none"> 1. Preliminary Investigation 2. Theoretical embedding 3. Empirical testing 4. Documentation, analysis, and reflection on process and outcomes
Clarke et al. (2016)	<ol style="list-style-type: none"> 1. Knowing the global-local context 2. Identifying student profile 3. Selecting core and adaptable content 4. Designing the curriculum 5. Delivering multiple offerings 6. Collecting performance data 7. Evaluating and reviewing curriculum
Young and Perović (2016)	<ol style="list-style-type: none"> 1. Introduction 2. Preliminary design 3. Representing learning types 4. Organizing the activities and assessment 5. Discussion and final presentation
IBE-UNESCO (2017)	<ol style="list-style-type: none"> 1. Evidence-gathering 2. Preparation 3. Development 4. Implementation 5. Monitoring and evaluation
Ornstein and Hunkins (2018)	<ol style="list-style-type: none"> 1. Theoretical foundation 2. Design 3. Development 4. Implementation 5. Evaluation

These methods, rooted in theoretical foundations, offer structured approaches to curriculum design to improve education quality. However, many documented experiences in curriculum design worldwide have yet to utilize these theoretically proposed methods. This disconnection between theory and practice raises questions about the practicality of these methods and highlights the need for further research to bridge this gap (OECD, 2020).

Our analysis reveals a divergence between the practices outlined in curriculum design theory and those implemented empirically. This discrepancy has led to different working methods and graphical representations of curriculum designs. Additionally, the lack of documentation of empirical experiences in curriculum design hampers the sharing and replication of knowledge. Furthermore, there is a need for observable and reliable verification of curriculum design practices to evaluate their efficacy and quality.

In response to the observed heterogeneity in curriculum design practices and representations, we aim to establish a theoretical foundation for curriculum design. We initially focused on computing-related academic programs using a software engineering approach through the Software Engineering Method and Theory (SEMAT) Essence kernel (OMG, 2018), resulting in the creation of the *ESSENTIA CURRICULUM*. To achieve this, a linguistic corpus is constructed from a comprehensive literature review and contributions from a community of 226 experienced curriculum design professors worldwide to identify common practices.

The distribution of universities and professors who participated in the survey covers practically all the world. The data involved in the research is summarized by continent, countries, universities, and professors involved in the survey. Africa has three countries with three universities and four professors participating. America is comprised of four countries, with 52 universities and 70 professors. Asia includes 14 countries with a total of 28 universities and 35 professors. Europe, the most diverse in terms of academic institutions, consists of 21 countries, 79 universities, and 105 professors. Oceania is represented by two countries, with eight universities and 12 professors. This brings the global total to 44 countries, 170 universities, and 226 professors participating in the survey.

We emphasize the concentration of survey participants in Europe and America, particularly the United States, which has the highest number of universities and professors. This is indicated by the significant cluster of dots and the notable section in the table. However, Asia has a substantial presence with fewer universities and professors than Europe and America. Africa and Oceania, on the other hand, display a much smaller number of academic institutions and personnel, highlighting the disparities in survey participation across different regions.

Our research involves a global distribution of survey participants, underscoring the regional disparities in academic engagement. It provides a clear and immediate understanding of where the survey respondents are concentrated and the relative academic personnel strength in these regions. It helps analyze global educational survey participation trends and identify areas that may benefit from increased academic outreach concerning curriculum design.

Subsequently, terminology unification begins, leading to proposed modifications to the SEMAT Essence kernel, forming the *EC-Nucleus*. As the core of *ESSENTIA*

CURRICULUM, *EC-Nucleus* includes elements for a language specification that is easy to understand and context-free, allowing its application beyond computing-related academic programs.

ESSENTIA CURRICULUM is grounded in computational linguistics analysis of a linguistic corpus, enabling the identification of common practices and unification of terminology to support curriculum design endeavors. The method is represented by ten common practices identified through the analysis, forming the foundation of this approach. These ten foundational practices and the curriculum design representations proposed by the community constitute a growing library called *EC-Bibliotheca*. Available online, *EC-Bibliotheca* is a resource for educators, curriculum designers, and practitioners to facilitate the sharing and adopting effective curriculum design practices based on common ground.

ESSENTIA CURRICULUM is a consistent approach to curriculum design validated in an academic scenario with favorable results, following the IEEE 1012–2016 standard (IEEE, 2016). This validation underscores the reliability and effectiveness of *ESSENTIA CURRICULUM*, reinforcing its usefulness in the academic community of the Ph.D. Program in Educational Sciences at the University of Nariño, where ten Ph.D. students participated in the validation process. Furthermore, *ESSENTIA CURRICULUM* lays the groundwork for developing specialized computing solutions leveraging natural language processing (NLP) in future scenarios. Its comprehensive definition as a system, theory, method, and model makes it a tool for advancing curriculum design practices.

Given the effort invested in developing learning outcomes as part of curriculum harmonization, we use the *ESSENTIA CURRICULUM* framework in this context. Proposed by Insuasti (2024), the *ESSENTIA CURRICULUM* framework is beneficial for representing practices from a project management standpoint. We employ its controlled language and its adaptability to various contexts. **Figure 1** illustrates the elements practitioners engage with within the framework rationale.

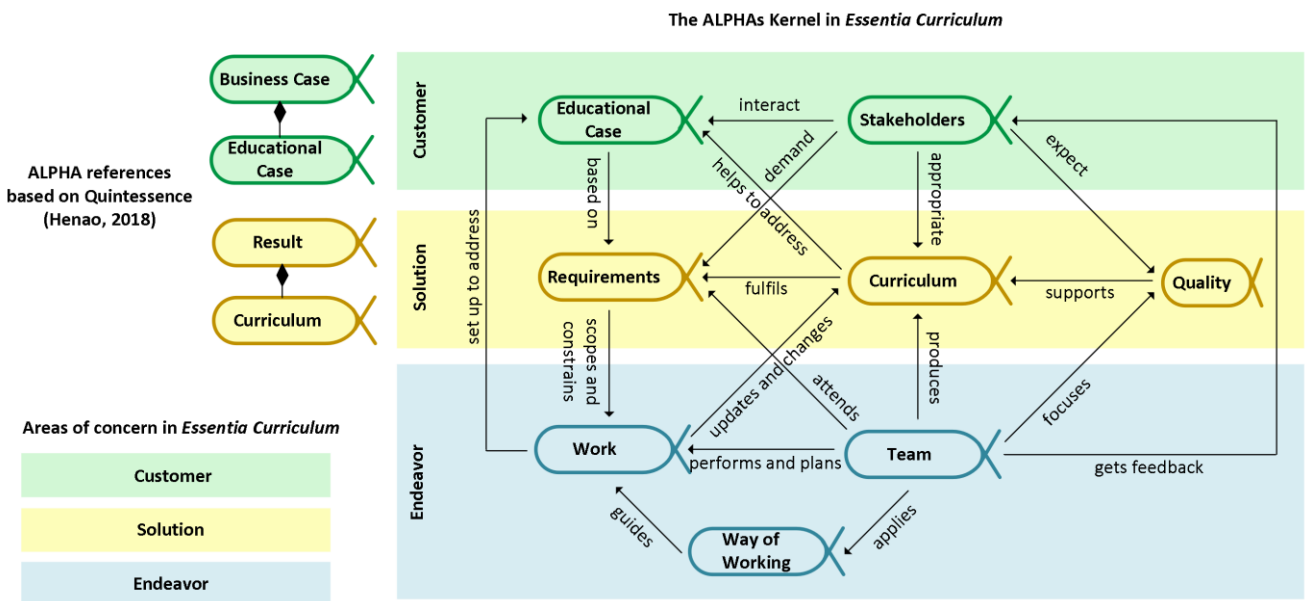


Figure 1. *ESSENTIA CURRICULUM* ALPHAs.

Source: The authors based on (Insuasti, 2024).

ESSENTIA CURRICULUM is based on the SEMAT Essence, a standard by the Object Management Group for depicting software engineering practices (Object Management Group, 2018), and it includes elements from Quintessence (Roqueme and de Jesús, 2018). SEMAT Essence is a framework designed to guide and improve the software development process. It comprises a common language and a kernel of widely agreed elements essential for all software projects, promoting a universal approach to software engineering (Object Management Group, 2018). *ESSENTIA CURRICULUM* is adapted from such frameworks to specifically focus on curriculum design, organizing the work around three primary areas of concern: customer, solution, and endeavor. Within such areas, *ESSENTIA CURRICULUM* includes ALPHAs to represent key elements consistently involved in curriculum design projects. Such ALPHAs are organized in their respective areas of concern. Furthermore, based on such areas of concern, *ESSENTIA CURRICULUM* includes a series of activity spaces describing steps to accomplish specific objectives with activities. **Figure 2** illustrates such activity spaces within the *ESSENTIA CURRICULUM* framework.

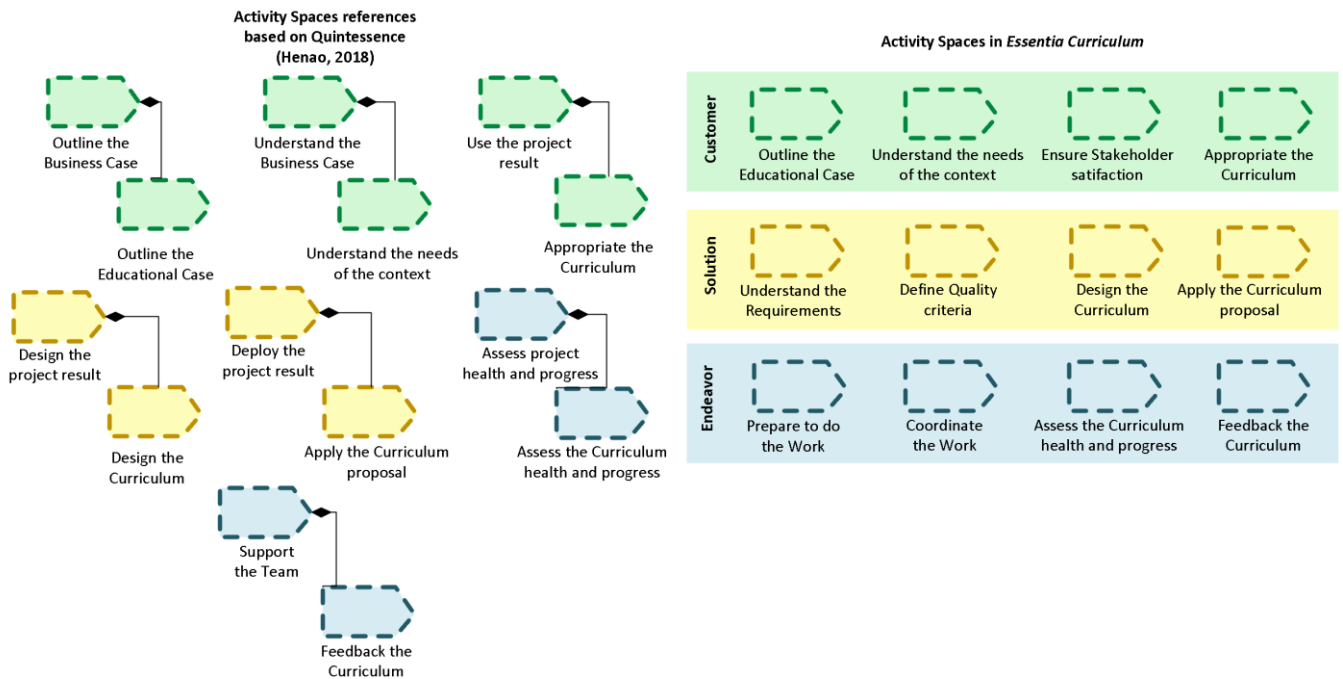


Figure 2. Activity spaces in *ESSENTIA CURRICULUM*.

Source: The authors based on (Insuasti, 2024).

Such elements serve as the foundational components of the practices within the *ESSENTIA CURRICULUM* framework. Accordingly, we utilize this framework for depicting the learning outcomes of the M.Sc. program in University Teaching at the University of Nariño.

Figure 3 shows the method we follow in our case study using the *ESSENTIA CURRICULUM* notation. As curriculum designers, we define the *ESSENTIA CURRICULUM* elements for representing the program learning outcomes, then representing the practices and establish relationships.

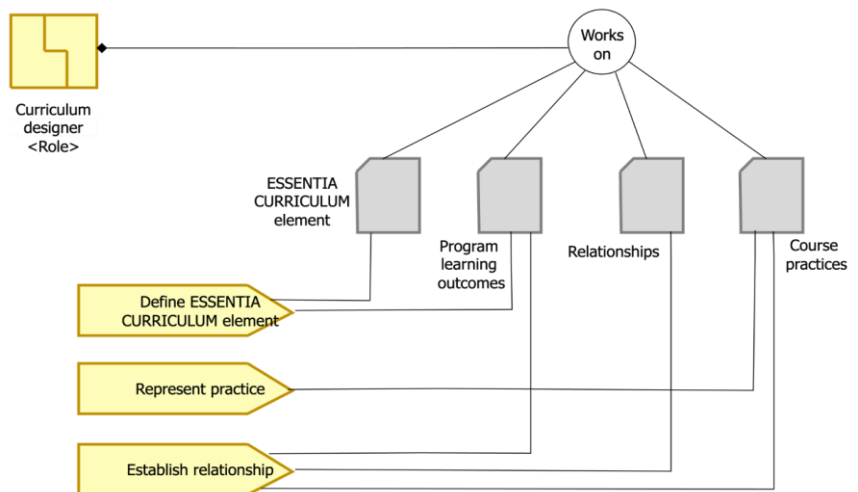


Figure 3. Our method is represented in the *ESSENTIA CURRICULUM* notation.
Source: The authors.

The learning outcomes for this graduate program are articulated in natural language and can be naturally represented using elements from the *ESSENTIA CURRICULUM*. In **Figure 4**, we show the learning outcomes represented within this framework.

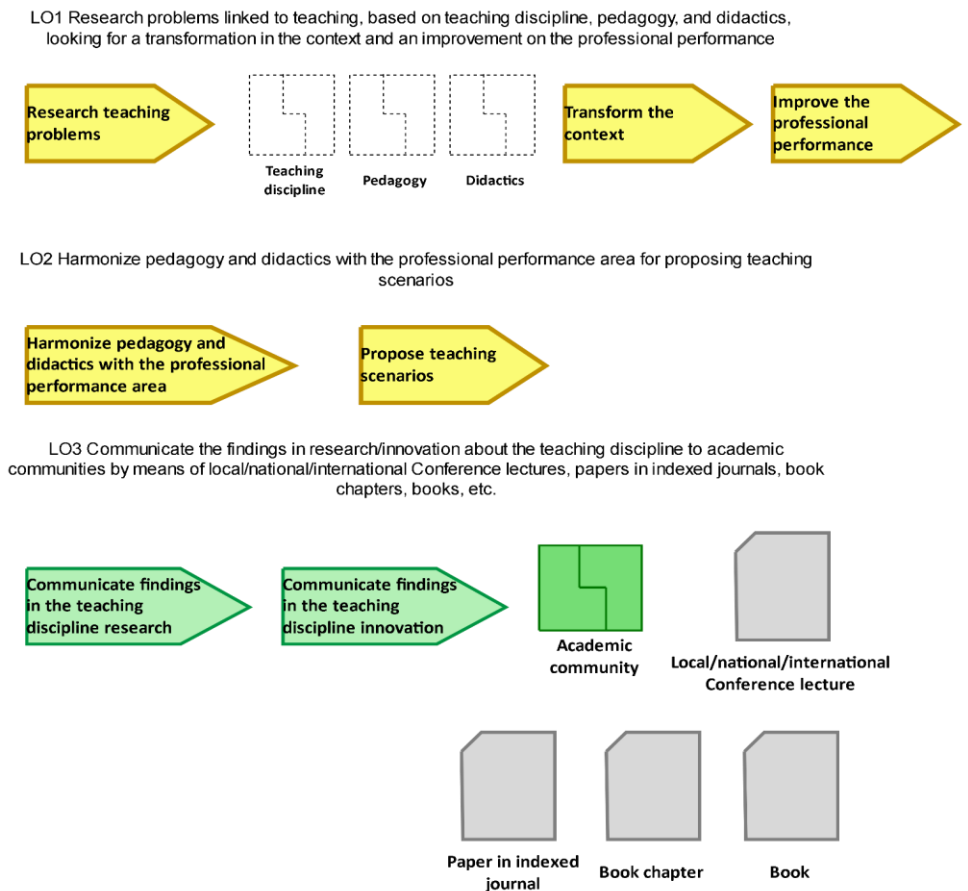


Figure 4. Learning outcomes of the M.Sc. program in University Teaching at the university of Nariño.
Source: The authors.

Such learning outcomes function as essential benchmarks shaping the curriculum design and the educational experiences students provide. They encapsulate the critical skills, knowledge, and competencies the students are expected to acquire by the end of the program.

Looking ahead, maintaining program quality, and ensuring alignment with academic and professional standards involves curriculum harmonization. This process entails coordinating the broader curriculum (macro) with the detailed course-specific curriculum (micro). It includes a comprehensive analysis of how the learning outcomes at the course level contribute to the overall program learning outcomes. By analyzing the learning outcomes of individual courses, such as the ICT for Research course, we can determine their effectiveness in supporting the broader program learning outcomes.

In our case study, we incorporate the contents of the ICT for Research course into the *ESSENTIA CURRICULUM* framework to illustrate the connections between the course-level and program-level learning outcomes. We treat such learning outcomes as practices within the *ESSENTIA CURRICULUM*, where the activities linked to each practice facilitate the establishment of relationships with the elements of the learning outcomes. We represent such relationships and the set of learning outcomes about the ICT for Research course by defining two practices called ‘Research-based definition of the teaching principles’ and ‘Systematic review of teaching literature,’ as depicted in **Figure 5a**.

In the same way, **Figure 5b** is showing the practice called “Systematic Review of Teaching Literature”. In curriculum design endeavors, such a practice involves a structured approach to examining scholarly articles and texts to identify and synthesize relevant information that informs teaching disciplines. The process starts with the design phase, where the overall project outcome is conceptualized. This phase contains multiple steps such as reviewing, analyzing, and organizing information to ensure a comprehensive understanding of the subject matter.

In this practice, higher education teachers play a pivotal role as they work on integrating findings from teaching literature into their curriculum development efforts. These findings are crucial for designing research schemas and ultimately lead to the generation of meaningful research results that can significantly enhance educational strategies and outcomes. The systematic review supports the teacher in aligning educational content with current academic standards and practices, aiming to improve both teaching methods and student learning experiences. This methodical approach ensures that curriculum development is both evidence-based and aligned with the latest educational research.

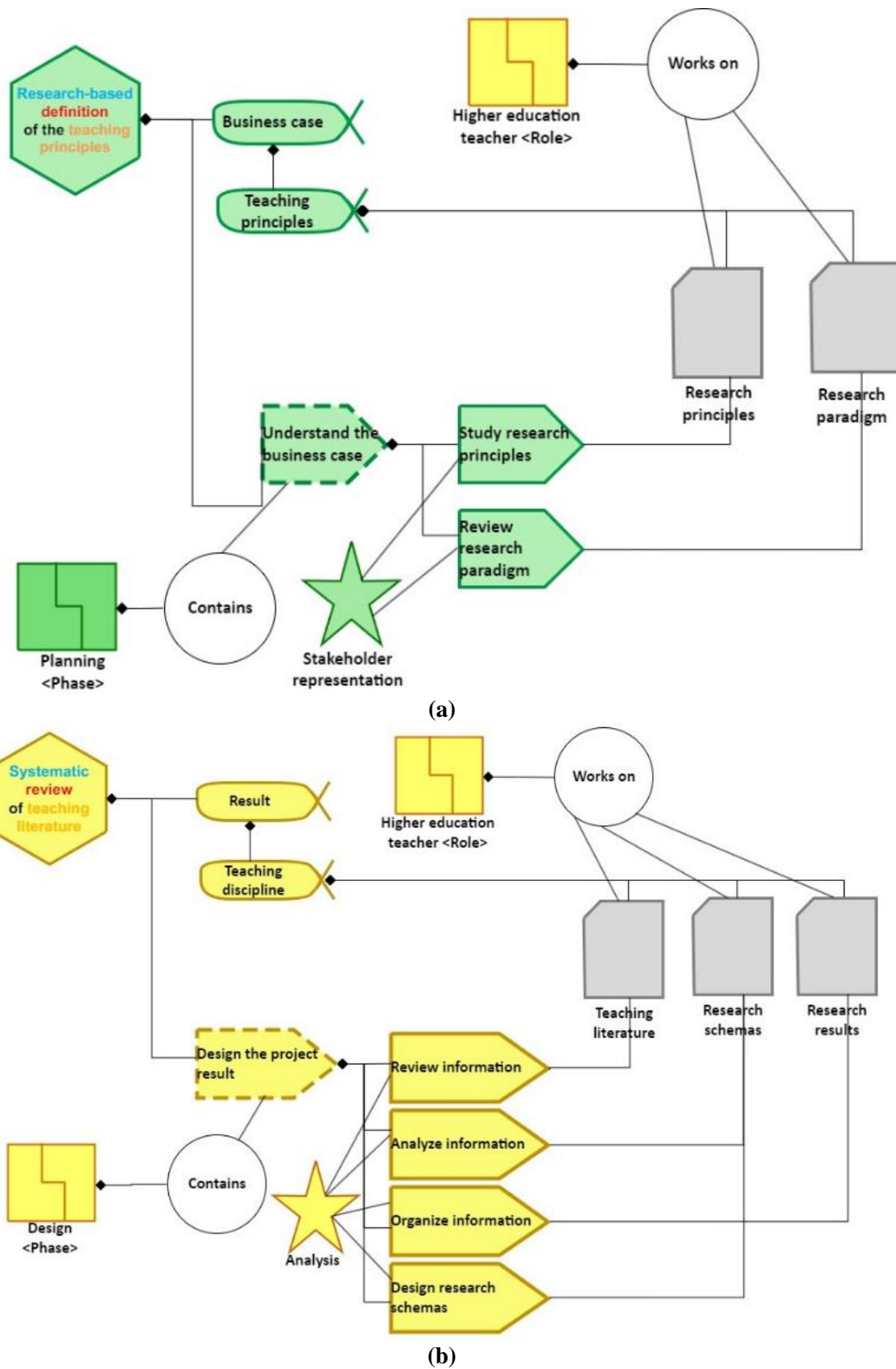


Figure 5. (a) Practices in *ESSENTIA CURRICULUM* for the ICT for Research course; (b) Practices in *ESSENTIA CURRICULUM* for the ICT for Research course.

Source: The authors.

We then employ a crosstab matrix to systematically organize the disaggregated components of the program learning outcomes across the columns (for the sake of simplicity, each component within a learning outcome is numbered). We present such a matrix in **Table 2**. The cells in the matrix show the relationship between pairs of elements, categorized by a level of interaction (high, medium, or low).

Table 2. Crosstab matrix considering the program learning outcomes and the ‘ICT for research’ course.

COURSE LEARNING OUTCOMES	PROGRAM LEARNING OUTCOMES														
	1						2		3						
	1	2	3	4	5	6	1	2	1	2	3	4	5	6	7
Research-based definition of the teaching principles															
Study research principles		H	H	H	H	L					L	L	L	L	
Review research paradigm		H	H	H	H	L					L	L	L	L	
Systematic review of the teaching discipline															
Review information	M	M	M	M		L	L				M	M	M	M	
Analyze information	M	M	M	M		L	L				M	M	M	M	
Organize information	M	M	M	M		L	L				M	M	M	M	
Design research schemas	M	M	M	M		L	L	M	M	M					

Source: The authors.

Our case study includes a thorough analysis covering both the drawbacks mentioned in the second section of this article and the advantages our proposal offers in addressing these issues, as outlined in **Table 3**.

Table 3. In-depth analysis of the case study.

Authors	Drawback	Advantages of our proposal
Komenda et al. (2015)	Lack of competency definition	Our case study clearly defines and uses competencies in the <i>ESSENTIA CURRICULUM</i> nomenclature.
Cahapay (2020) Berutu et al. (2024)	Disconnection between skills taught and actual needs.	Each of the <i>ESSENTIA CURRICULUM</i> representations includes competencies linked to the activities. They are aligned with our method and the National Accreditation Council guidelines.
Ball et al. (2007)	High subjectivity due to the differences in models of each country	Using <i>ESSENTIA CURRICULUM</i> , it has been possible to unify the representations regardless of the heterogeneity of definitions of the contexts.
Ebako and Molindo (2023)	Cultural diversity is a challenge.	The definitions of practices supported in <i>ESSENTIA CURRICULUM</i> lack bias in multicultural scenarios.
Munadi et al. (2021)	Difficulties for curriculum implementations in terms of curriculum flexibility.	The formal definition based on <i>ESSENTIA CURRICULUM</i> eases the implementation of curriculum designs and flexibility processes.
Bezić et al. (2020)	Informal definition of harmonization.	The crosstab matrix of our method is a formal definition of harmonization according to our method.
Alemu (2023) Lokossou et al. (2021)	Descriptive models are not standard.	Our case study includes <i>ESSENTIA CURRICULUM</i> , a standardized way to define the curriculum for harmonization purposes.

Source: The authors.

The literature review highlights some global examples of curriculum harmonization efforts but consistently identifies a common challenge: aligning the learning outcomes of academic programs with those of individual courses. Such

alignment is vital for ensuring that broad educational objectives are consistently represented at the course level. Our approach addresses this issue by integrating principles from software engineering, project management, and computational linguistics supported by LLMs—Large Language Models—(Insuasti et al., 2023). By utilizing the *ESSENTIA CURRICULUM* in our specific case study, we establish a direct correlation between the learning outcomes at the program and course levels. This strategy enhances curriculum coherence and introduces a new educational planning and assessment paradigm.

Validation

Accreditation policies in Colombia are critical to ensuring the quality of academic programs in higher education. Such policies are overseen in Colombia by the National Accreditation Council (CNA in Spanish), responsible for evaluating the quality of undergraduate and graduate programs nationwide. The accreditation process involves a comprehensive review of the institution's educational offerings, faculty qualifications, research outputs, infrastructure, and student services. Programs meeting the CNA set standards are granted accreditation, a mark of quality and reliability, assuring students and employers of the program's excellence. This process helps maintain high educational standards and promotes continuous improvement and accountability in Colombian higher education institutions.

The M.Sc. program in University Teaching at the University of Nariño has a self-assessment process for reaccreditation purposes, according to the guidelines proposed by the CNA. In this sense, such a self-assessment process includes documentary review activities and the application of surveys to the different actors involved in the academic community of the M.Sc. program in University Teaching, such as professors, students, graduates, administrative staff, and employers.

According to the CNA guidelines in Colombia, factor number 5 deals with academic aspects and learning outcomes. In addition, characteristic number 23 directly addresses learning outcomes (CNA, 2022). By conducting the documentary review processes together with the interviews with ten professors, 26 active students, and 98 graduates from the alumni, there has been a favorable result regarding assessments on the articulation of learning results since the curriculum harmonization process was applied. Such results can be observed in **Figure 6**.

The documentary review exercise has provided sufficient evidence about the existence of the learning results after the curricular harmonization process. The appreciation of both the professors and the active students is practically high. However, the appreciation of the alumni members is somewhat lower given that, at the time, they were linked to the M.Sc. program, the concept of learning outcome. However, everything was managed with a competency-based approach.

The results are favorable, reflected in the self-evaluation report to re-accrediting the M.Sc. program in University Teaching at the University of Nariño 2024, which is still under construction.

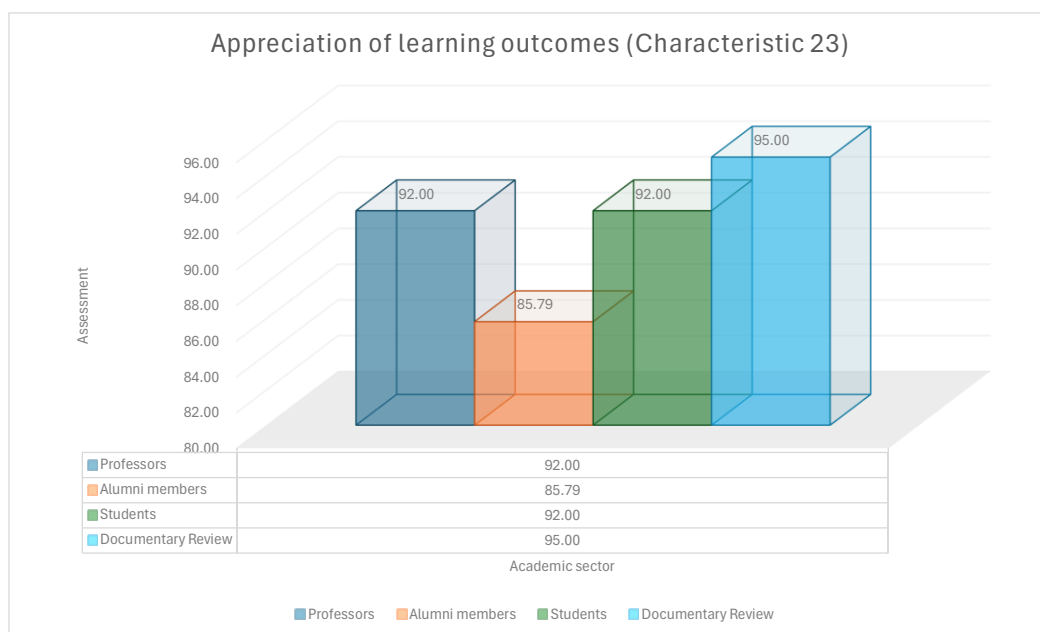


Figure 6. Appreciation of learning outcomes (characteristic 23).

Source: The authors based on the self-assessment report with a view to re-accrediting the M.Sc. program in University Teaching of the University of Nariño, 2024.

4. Results and discussion

4.1. Discussion

The findings of this study demonstrate the efficacy of the *ESSENTIA CURRICULUM* framework in harmonizing course-specific and program-wide learning outcomes within the context of the ICT for Research course in the M.Sc. program in University Teaching at the University of Nariño. However, while these results are promising, several limitations must be acknowledged to provide a balanced interpretation of the study's contributions.

This study focuses on a single course within a specific graduate program at a single institution. While the *ESSENTIA CURRICULUM* framework is practical in this context, its applicability to other academic programs, disciplines, or institutions remains in an exploratory state. This narrow scope limits the generalizability of the findings. Additionally, the reliance on qualitative analysis and case study methodology, though suitable for in-depth exploration, may introduce subjectivity in interpreting results. The absence of a comparative analysis with alternative curriculum design frameworks limits the ability to evaluate the relative strengths of *ESSENTIA CURRICULUM*. Although the study included feedback from various stakeholders, including professors, students, and alums, the sample sizes for each group were small. This limitation could affect the robustness of the conclusions drawn about stakeholder perceptions. Furthermore, the study assesses the harmonization process and stakeholder feedback simultaneously. The long-term effects of implementing the *ESSENTIA CURRICULUM* framework on student learning outcomes, teaching effectiveness, and program quality were not evaluated.

To build on this study's findings and address its limitations, expanding the application of the *ESSENTIA CURRICULUM* framework to include diverse academic

programs, disciplines, and institutions will help assess its generalizability and adaptability. Comparative studies with other curriculum harmonization frameworks could further establish its efficacy. Quantitative research methods, such as statistical analyses of student performance data or large-scale surveys of stakeholder perceptions, could provide more objective and generalizable insights into the framework's impact. Future studies should aim to involve larger and more diverse groups of stakeholders, including industry representatives and policymakers, to gain a comprehensive understanding of the framework's strengths and limitations. Conducting longitudinal research to track the framework's impact over time would provide valuable insights into its sustained effectiveness in improving curriculum coherence and learning outcomes. Investigating the potential for integrating advanced technologies, such as artificial intelligence and data analytics, into the *ESSENTIA CURRICULUM* framework could enhance its ability to adapt to evolving educational demands and provide personalized learning experiences.

While this study represents a significant step toward bridging the gap between course-specific and program-wide learning outcomes, the limitations identified underscore the need for continued research. By addressing these limitations and pursuing the proposed research directions, future studies can refine and extend the *ESSENTIA CURRICULUM* framework's application, contributing to the broader goal of enhancing educational quality and coherence across diverse contexts.

4.2. Future work

As a line of future work, we propose discussing professional profiles associated with the program using the *ESSENTIA CURRICULUM* competencies. Our representations delineate roles such as professors, students, pedagogues, administrators, academic peers, and curriculum reviewers. While the differences between these roles may be subtle, they are commonly recognized in the educational landscape. By utilizing *ESSENTIA CURRICULUM*-based profiles, we can clearly define the characteristics of these roles within the program. Similarly, this approach can be extended to various other roles professionals may assume in an educational context.

We also define a method to justify the learning outcomes of these profiles. The *ESSENTIA CURRICULUM* competencies have five levels to assess the students' initial competency levels against the final competency levels of a graduated professional.

Moreover, the *ESSENTIA CURRICULUM* framework provides the necessary elements to represent any other curriculum. Consequently, we can easily apply it to represent other engineering programs or even programs in other disciplines.

This case study can be extended to all courses within the program to assess the overall achievement of the program learning outcomes. Furthermore, this approach benefits any accreditation process; in our case, we work with guidelines proposed by the CNA in Colombia. However, the features are universal to any accreditation bureau in other places.

5. Conclusions

In this article, we developed a case study for representing the harmonization of learning outcomes of the M.Sc. program in University Teaching at the University of Nariño within the ICT for Research course, which is part of such a program. We employed the *ESSENTIA CURRICULUM* framework as a unified basis for representing both the program-wide and course-specific learning outcomes, with the latter shaped as practices. Subsequently, we compared the course learning outcomes with the program learning outcomes. This comparison helps determine how the course outcomes support the fulfillment of the program objectives. Additionally, we suggest ways to enhance synergy among the elements of different courses to achieve the program learning goals more effectively.

The learning outcomes respond to the review of the Educational Project of the Program, its restructuring, the competencies expected of graduates, and the professional profile. In addition, the self-evaluation processes of the Program performed between the years 2017—2019, the results of the improvement plans, and the suggestions of the external peer evaluators in 2019 have also been considered. The method for harmonizing the program learning outcomes with the course learning outcomes using *ESSENTIA CURRICULUM* was helpful. In this regard, the students', alumni members', and professors' appreciation for the program's declaration of learning outcomes is high, according to the survey.

This study highlights the effectiveness of the *ESSENTIA CURRICULUM* framework in aligning course-specific and program-wide learning outcomes, demonstrated in the ICT for Research course within an M.Sc. program at the University of Nariño. However, its scope is limited to a single institution and course, raising new opportunities about its broader applicability. Reliance on qualitative methods and small stakeholder samples introduces subjectivity and limits the robustness of conclusions to generalize them, while long-term impacts remain unexplored. To enhance its relevance, future research should expand the framework's application across diverse contexts, employ quantitative methods, involve a wider range of stakeholders, and explore integration with advanced technologies like AI and data analytics. These efforts could refine the framework, making it a scalable solution for improving curriculum coherence and educational quality globally.

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